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Biology 30

The Nervous System

Module 1



Distance
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Biology 30

Module 1

The Nervous System



**Distance
Learning**

Alberta
EDUCATION

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Administrators	
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Other	

Biology 30
 Student Module
 Module 1
 The Nervous System
 Alberta Distance Learning Centre
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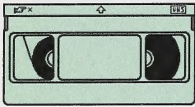
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Welcome to Biology 30!

We hope you'll find this course interesting and fun. To make your learning a bit easier, watch the referenced videocassettes whenever you see this icon.

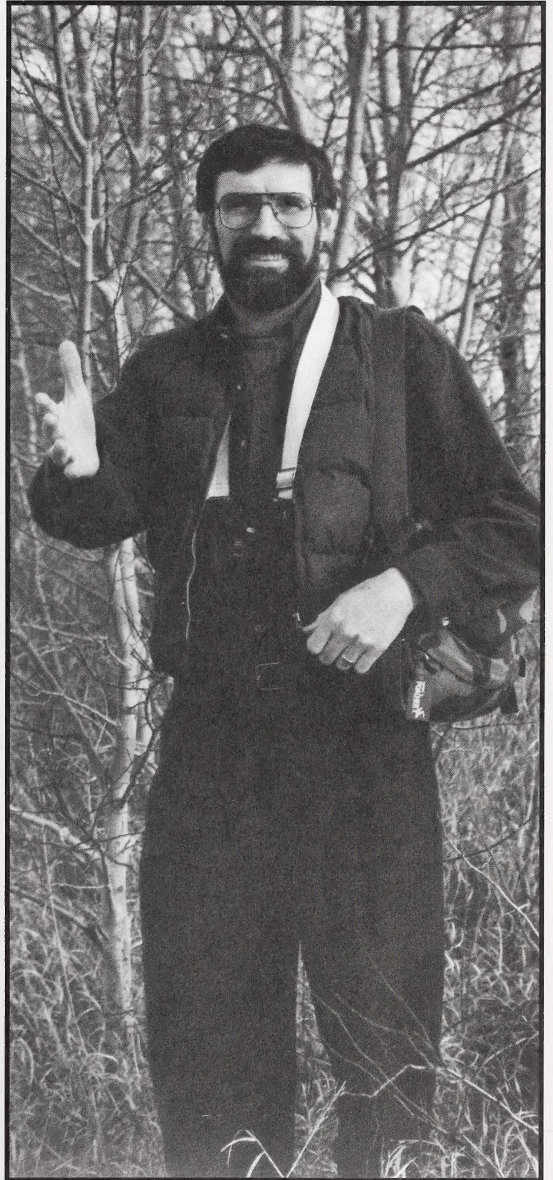
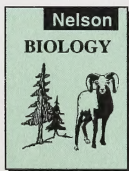


You also have the option of viewing laser videodisc clips when you see a bar code like this one.



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When you see this icon, study the appropriate pages in your textbook.

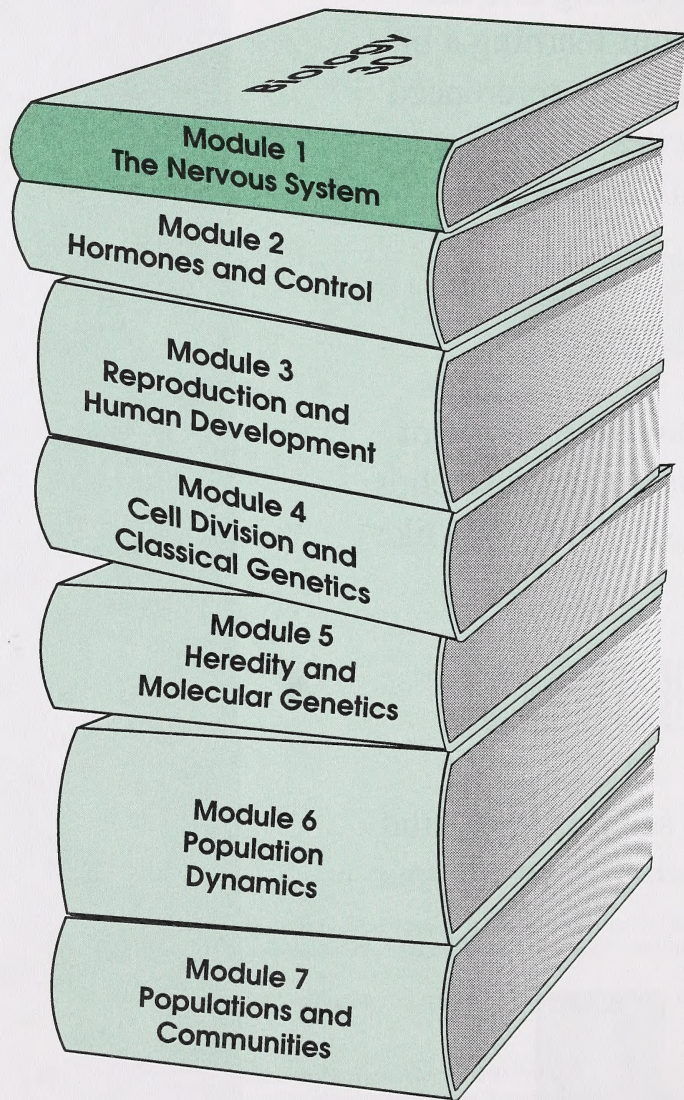


Good Luck!

COURSE OVERVIEW

This course contains seven modules. The module you are working in is highlighted in a darker colour.

Biology 30



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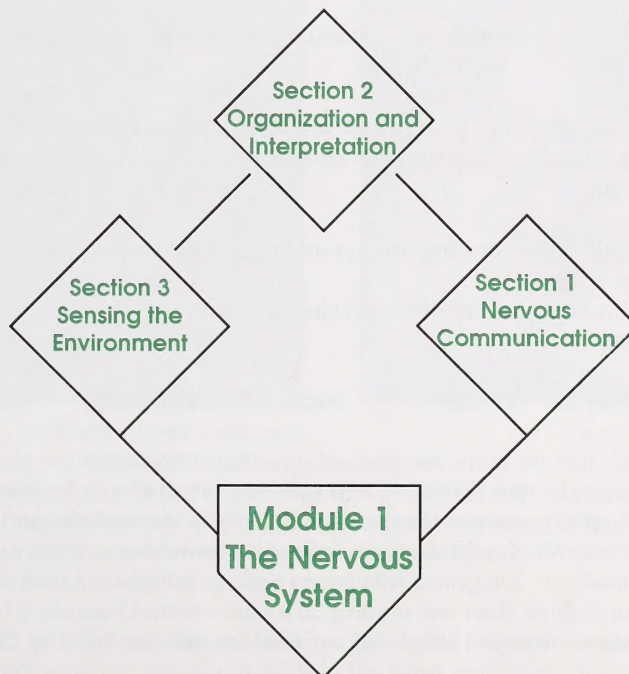
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MODULE OVERVIEW

Olsen was on first, Peters was on second, and the count was three balls and two strikes. The pitch came in level and just a bit inside. Bradley hit a ground ball down the third base line. An expert at grounders, Connors scooped it with her toe still firmly on the base. Then in one smooth motion she threw the ball to second base. Peters was two steps into flight when the ball whizzed past his ear and smacked into Owens's glove. That made two out. From the corner of his eye, Owens saw Olsen sliding into second. He leaped up and to the side; and hurled the ball towards first. Olsen slid under Owens as the ball beat Bradley to first by exactly one stride. The total was three out in one coordinated blink of an eye. The crowd went wild. How did they do it? "Raw nerve and great coordination," said the coach with a grin.

Actually, if the truth be known in a biological sense, it was due to raw nerve and great coordination; a case of stimulus and response; action and reaction; and not dropping the ball. The human body contains a complex nervous system that receives and processes stimuli and coordinates responses in fractions of seconds. Baseball and many other sports are perfect places to see the nervous system in action. In this module you will study the main components of your nervous system and the way your body receives and processes information about the world around you.



Evaluation

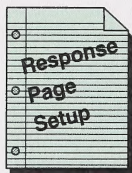
Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module you are expected to complete three assignments. The mark distribution is as follows:

Section 1 Assignment	35 marks
Section 2 Assignment	30 marks
Section 3 Assignment	<u>35 marks</u>

TOTAL 100 marks

When doing your assignments, work slowly and carefully. If you are having difficulties, go back and review the appropriate section.

Read all parts of your assignment carefully. Plan and do your rough work on your own paper. Revise and edit your responses; then set up your final copy for submission on your own paper. Lined looseleaf is recommended. Make sure your answers are neat and organized, with wide left margins and space for teacher comments after each assignment.



When you see this icon, ideas and details are provided to help you set up and organize your answer in a certain way.

Before submitting your responses, be sure to proofread them carefully to ensure they say what you want, that they are neat and clear, and that they are complete and missing no material.

You will be submitting **only** your **assignment response pages** for evaluation.

It is important to number and clearly identify each page with this information placed at the top.

Biology 30 – Module 1 Section # Assignment Page # Name and ID #

Notice that for some assignment questions two marks are given for communication. This is indicated at the end of a question. For two marks your response should clearly and logically answer the question and show strong linkages between cause and effect. Your answer should consist of complete sentences and use appropriate scientific terminology. Diagrams may be an appropriate part of your answer. An answer that requires more than one reading to be understood because it has only weak linkages between cause and effect and contains inconsistencies may only be awarded one mark or less.

Science Skills

One of the exciting features of this course is that you will develop and improve your ability in science skills. These skills include

- initiating and planning
- collecting and recording
- organizing and communicating
- analysing
- connecting, synthesizing, and integrating
- evaluating the process or outcomes
- others

Although these skills are referred to as science skills, it is important to remember two key ideas.

First, these skills are not just for science. Any time that you solve a problem or make a decision, some combination of these skills will be used.



COURTESY OF TERRY SLIWKANICH



COURTESY OF TERRY SLIWKANICH

Therefore, the skills you will develop in this course will be very useful for life-long learning. Nearly every activity of your life will require you to solve a problem or make a decision. Some people would even argue that, in the long run, the skills are more important than the particular topics that you study.

Second, you will be free to use these skills in a variety of ways. It would be wrong to assume that every scientist uses these skills in the same way to solve a problem. Science is very much a human activity, which means individuality and creativity play a large role.



NASA



NRC/IMS

The society that the person lives in, the technology that is available, and the very personality of the scientist will determine which skills are combined to create a solution to a problem.

It follows from this idea that the science that you do and the science skills that you prefer to use will be unique to you. It also follows that you likely will not be performing at the same level for all skills. In this course you will continually practise all of these skills and you will have an opportunity to assess your level of performance.

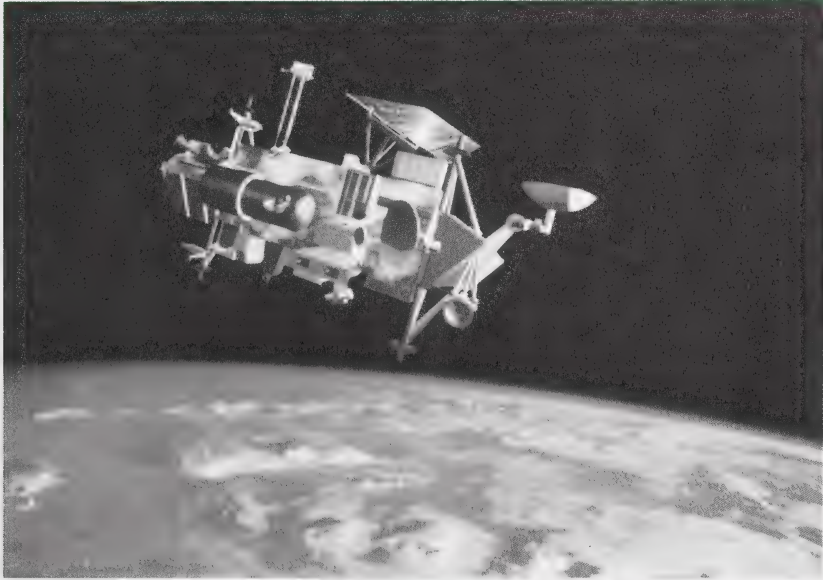
These science skills will be developed further in Activity 1 and explained in detail in the Appendix for this module. Practice in science skills occurs in all modules and is important for assignments and exams.

Important Note

There are no response lines to write on in many of the questions asked in the student module booklets of this course. This means that you will need to have lined paper handy at all times on which to answer the questions. You will also require your own graph paper. It's probably a good idea if you keep your answer pages in a binder so they are easier to refer to when reviewing. Read all the questions carefully and answer them as completely as possible. Then check your answers in the Appendix. This will allow you to assess your growing abilities in this course.

It is also important that you work through the module activities thoroughly before attempting the questions in the assignments. This will help you to achieve a greater degree of success in your studies.

Nervous Communication



NASA

Have you ever wondered how it is possible to simultaneously talk on the phone to relatives in British Columbia, New York, and Europe? It is amazing how technology allows instantaneous communication over thousands of kilometres. The systems of telecommunications and satellite broadcasting have brought the world into your house.

As incredible as this technology is, your nervous system outperforms these advanced systems and communicates faultlessly most of the time!

In this section you will investigate the nervous system. Pathways and messages will be analysed to help you understand the speed of transmission and the coordination of responses in your body.

You will also study science skills that are developed and used throughout this course. The first activity will introduce you to how science skills are recognized, practised, and evaluated. Then you will begin your study of the nervous system.

ACTIVITY

1 Science Skills

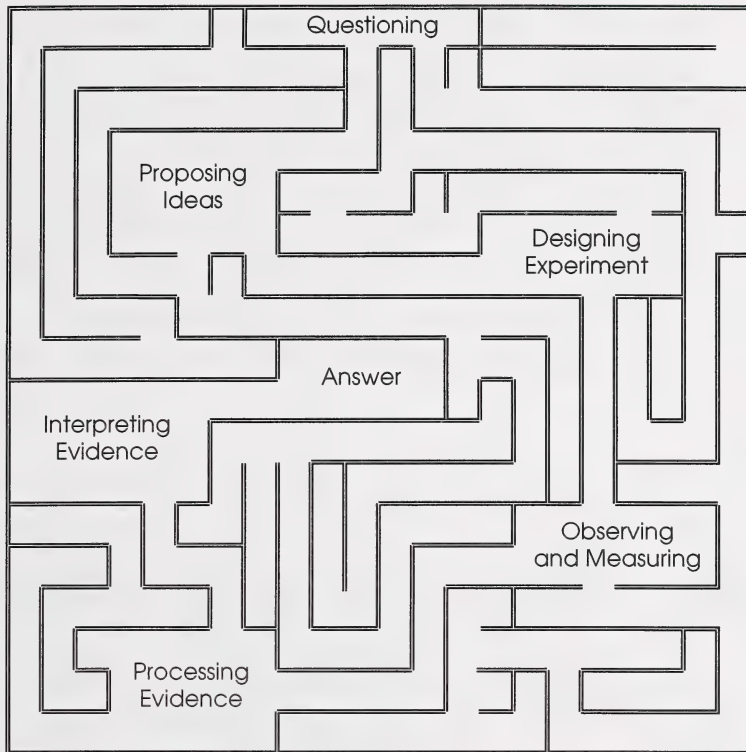
Science is not just concerned with the accumulation of knowledge. It is also concerned with carrying out scientific investigations that solve problems and answer questions. This is called research. The activities used while doing research or solving problems are commonly referred to as science skills. These are fundamental to the methodology of science. Scientists and science students use their science skills to help them find reliable answers to the questions about the world around them.



COURTESY OF TERRY SLIWKANICH

Science skills can be organized in a logical sequence that leads from a problem or question through investigations to solutions or answers. The steps are very useful.

1. Carefully follow the maze to find the sequence of science skills. Start with Questioning and work your way in to the Answer.



2. Make a list of the science skills so you can clearly see the correct sequence.

Check your answers by turning to the Appendix, Section 1: Activity 1.

You'll learn and practise science skills throughout Biology 30. Science skills may also be a part of your section assignments and final examinations. Hopefully they will become a part of the way you do science.

Science Skills for Biology 30

Following is a list of general science skills developed in this course. A more detailed explanation of each skill is given in the Appendix of this module.

- A. Initiating and planning
- B. Collecting and recording
- C. Organizing and communicating
- D. Analysing
- E. Connecting, synthesizing, integrating
- F. Evaluating progress or outcome

As a student in science you may only use certain skills at certain times. You are not expected to be an expert in the very beginning. Good skills take time to develop and they improve with practice and experience. To help you keep track of your growth in science skills, take a look at the skill levels in the Appendix. Compare Level 1 to Level 4 under A. *Initiating and Planning*. Notice how the skill level changes. Level 5 may be expected of students in college or university. As a senior high school student you may already have some skills at Level 3 or 4. Can you draw a graph correctly? Check Level 3 in C. *Organizing and Communicating* in the Appendix. Science skills are developed in Biology 30 in a user-friendly way. Throughout the modules, skill icons will tell you when particular skills are applied. Notice the skill icon beside the investigation Reflex Arcs and Reaction Rate from Section 1, Activity 2. In this investigation you will practise collecting and organizing data on your nerve reflexes.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Now turn to question 12 in the assignment for Section 1. Do not try to answer the question at this time, but look at the skill icon. In this question you will be practising, organizing, analysing, and synthesizing information. Also notice the self-assessment instructions after the question. The self-assessment of your science skills is an opportunity for you to communicate your level of skill development to your teacher marker.

Assume that after answering question 12 you felt your skills were quite good so you constructed a skill assessment box and filled it in like the one that follows.

Self: A.	B.	C. 4	D. 4	E. 3	F.
Teacher: A.	B.	C.	D.	E.	F.

And when the teacher assessed your science skills they indicated this:

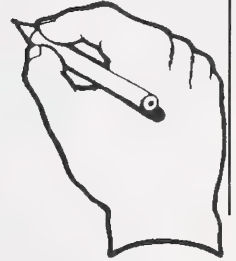
Self: A.	B.	C. 4	D. 4	E. 3	F.
Teacher: A.	B.	C. 3	D. 3	E. 4	F.

By comparing your assessment to the teacher assessment you can see they are very close. A little improvement could be made in Skills C and D but in Skill E you are at Level 4 already. A good start! The teacher marker may write you a short note explaining any differences.

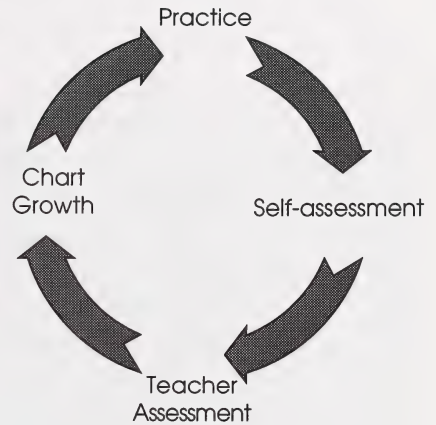
Now you would record both your assessment and the teacher assessment on the data sheet at the back of the Module 1.

SKILL ASSESSMENT RECORD

Feedback from Assignments			Initiating and Planning		Collecting and Recording		Organizing and Communicating		Analysing		Synthesizing and Integrating		Evaluating	
Module	Section	Question	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher
1	1	12					4	3	4	3	3	4		



Will these science skill levels affect my grade on this assignment?



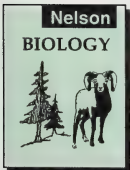
It is important for you to realize that the teacher skill-level assessment should **not** be interpreted as part of your grade. Rather, it is valuable feedback to help you to know the areas where you need to improve. Everyone can improve science skills.

How easy is it to identify science skills? Read Research in Canada on page 167 in your text and answer the following questions.

3. What is a likely question this research team is asking?

As a science skill, questioning includes clearly defining the problem in terms of variables. There are three main types of variables in science.

- **manipulated variable** – something the investigator chooses to change
- **responding variable** – something that changes because of the manipulated variable



- **controlled variable** – all other variables that are controlled so that only the manipulated and responding variables can be studied
4. Identify two manipulated variables that the research team will use.
 5. Identify the responding variable that will be studied.
 6. Describe three possible controlled variables the research team may monitor.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Once the variables are clearly identified and the problem is defined, ideas can be proposed for an investigation. A good proposal will contain background information, an hypothesis, and a prediction.

7. Briefly describe the background information given in the reading on page 167.

An hypothesis is a very important part of any research proposal. A good hypothesis will have three main components:

- It will offer an answer to the problem.
 - It will provide a reason or explanation.
 - It will be testable by an experiment or investigation.
8. Write a brief hypothesis that the research team might use. Include each of the three parts in your answer.

Check your answers by turning to the Appendix, Section 1: Activity 1.

9. What is the prediction made by the research team?

If a research proposal is good, and in science this may mean it will receive financial support, the next step in the process is to design the investigation.

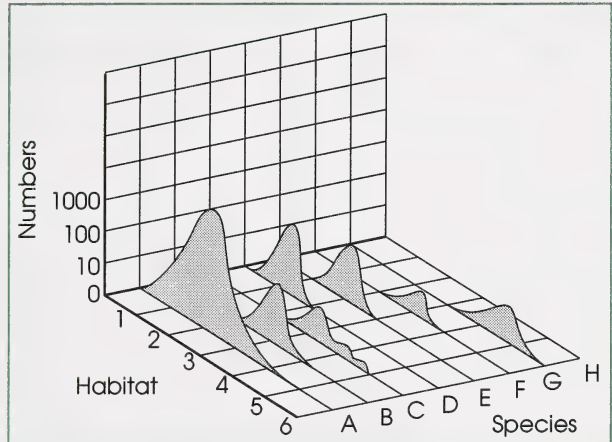
10. Basically, what will the research team do to test their hypothesis?
11. Describe the kind of data you think the team will collect.

After making observations and collecting data, many mathematical applications can be used to analyse the evidence. You've probably encountered some basic analytical techniques in previous courses. You'll learn much more about the analysis of data as you study science.

12. Name three possible ways scientists may analyse and display their data.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Graphing is a big part of processing evidence because it offers a visual display of information and relationships. Graphs may be line graphs, bar graphs, two- or three-dimensional graphs or other variations. Have you ever seen a computer-generated graph like the one shown here? There are ten basic rules to good graphing that will help you get the most from your information.



The Ten Rules for Graphing

1. The name of the manipulated variable and its unit of measure is placed on the horizontal axis.
2. The name of the responding variable and its unit of measure is placed on the vertical axis.
3. The values for the scales are calculated so that the plotted data extends over most of the graph. All plotted points must fit on the graph paper.
4. The scales need not be the same along both axes.
5. In most cases the scales should start at zero.
6. The coordinate points for the manipulated and responding variables are plotted on the graph.
7. The number pairs are plotted as points and the points are circled. The circle represents your possible error in calculating the location of that dot. (line graph)
8. The circles (not necessarily the dots) are joined by a smooth curve or line. (line graph)
9. A legend should be placed in the lower right hand corner of the graph if you are plotting two or more variables. The legend should identify each of the lines on the graph.
10. The title of the graph is written across the top of the graph paper. (Note: The title should indicate the relationship between the manipulated variable and the responding variable.)

Science Skills

- ☐ A. Initiating
☐ B. Collecting
☒ C. Organizing
☐ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

13. Use the following data to draw a line graph of the incidence of breast cancer in North American women.

Age of Women in Years	New Cases of Breast Cancer in 1990
20	0
25	7
30	21
35	60
40	121
45	121
50	134
55	127
60	148
65	150
70	117
75	93
80+	115



14. Construct a bar graph from the following *hypothetical* data on the incidence of breast cancer and dietary fat intake for two populations.

Incidence of Breast Cancer per 100 000 Women Correlated with Dietary Fat Intake		
Age group	Low dietary fat	High dietary fat
0 – 25	1	5
26 – 30	3	15
31 – 35	10	48
36 – 40	38	100
41 – 45	64	123
46 – 50	92	163
51 – 55	112	152
56 – 60	136	200
61 – 65	160	218
66 – 70	145	225
71 – 75	170	205
76 – 80	180	217

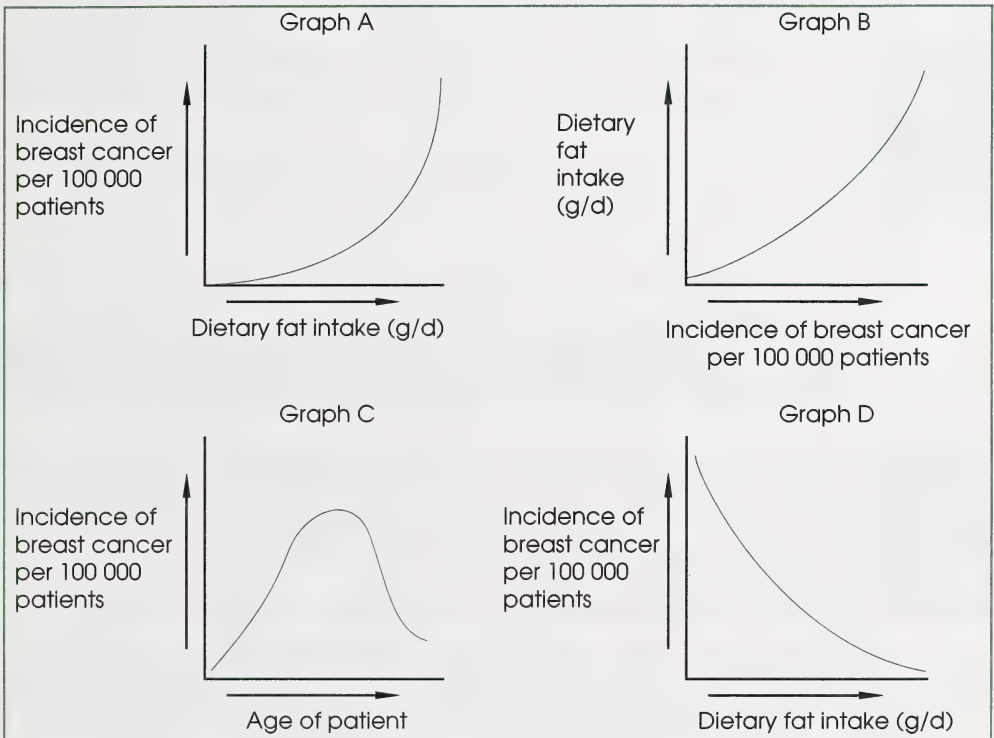
Check your answers by turning to the Appendix, Section 1: Activity 1.

¹ Alberta Cancer Registry 1990 Annual Report. Reprinted by permission of Alberta Cancer Board.

² Adapted from Alberta Cancer Registry 1990 Annual Report. Reprinted by permission of Alberta Cancer Board.

Evidence gathered during an investigation may or may not prove that the hypothesis is correct. After all, it's only an hypothesis. In some cases negative data can be just as important as positive data. It may lead to new questions or discoveries. Sometimes data that does not support the hypothesis may indicate an error in design or data collection. Other times it may indicate that the hypothesis is indeed false. This is the true nature of science.

Examine the following graphs and answer the next question.


Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

15. a. Which graph supports the hypothesis that the incidence of breast cancer increases with dietary fat intake?
- b. Explain why each of the three graphs you did **not** choose for an answer in the previous question do not support the hypothesis.

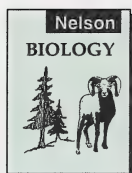
Check your answers by turning to the Appendix, Section 1: Activity 1.

So now you've had an introduction to science skills. Are you ready to begin your study of the nervous system? Go on to the next activity.

ACTIVITY

2 Neural Circuits

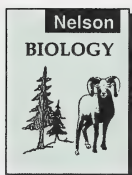
The nervous system is much like the intercom system of a school. It provides a quick, short-lived mechanism for transmitting information from one place to another. This instantaneous flow is essential for the proper functioning of a school just like it is for your body.



The importance of the nervous system and its basic organization are described on pages 350 and 351 in your text. After reading these sections, answer the following questions.

1. What components of the human nervous system are often used to illustrate its advanced development?
2. Differentiate between the CNS and PNS.

Check your answers by turning to the Appendix, Section 1: Activity 2.



To learn about the basic structural and functional units of the nervous system, read the sections entitled Neurons on pages 351 to 353 and Neural Circuits on page 353 and 354 of your text. Pay particular attention to Figure 15.3 on page 352. When you have finished reading, answer the following questions.

3. Compare the functions of each term in the following word pairs.
 - a. sensory neuron – motor neuron
 - b. dendrite – axon
 - c. myelin sheath – neurilemma
4. Interneurons or association neurons are found exclusively in the central nervous system. Illustrate the structure of this type of nerve cell with a labelled diagram.
5. Describe the relationship that exists between **myelination** and speed of transmission.
6. Distinguish between a neuron and a nerve.

myelination – having a myelin sheath around a neuron

Check your answers by turning to the Appendix, Section 1: Activity 2.

Investigation: Nerve Action

Objective

photomicrograph – a photograph of the magnified image of an object

In this investigation you will observe **photomicrographs** of actual neurons. By comparing the structures you observe, you can begin to infer their functions.

Materials

- microslide viewer
- microslide set 221, Nerve and Muscle Action

Procedure

- Observe slides 1 to 6 very carefully after reading the descriptions.

Observations

- On a separate piece of unlined paper, draw a diagram of slides 1 to 4 inclusive. Identify each part listed by an appropriate label on your diagrams:

- | | | |
|-------------|--------------------|---------------------|
| • cell body | • dendrite | • Schwann cell |
| • axon | • nodes of Ranvier | • neurilemma |

Analysis and Interpretation

- Describe a synapse and a neuromuscular junction.
- Compare the structure and function of sensory neurons and motor neurons.

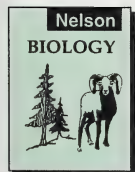
Check your answers by turning to the Appendix, Section 1: Activity 2.

Stand in front of a mirror and look carefully at your eyes. Now cover one eye. What happens to the black central circle, your pupil? That's right – it enlarges! This is an example of the simplest nerve pathway – a reflex arc. To learn more about the pathway of nerve impulse transmission, read the section entitled Neural Circuits on pages 353 and 354 in your text.

- Trace the pathway of the withdrawal reflex illustrated in Figure 15.5 by naming the five components of the reflex arc, starting at the stimulus.
- Explain why reflex arcs are involuntary and often unconscious.



neurilemma – the cell membrane surrounding a Schwann cell of a myelinated neuron

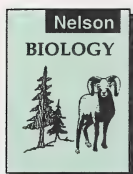


Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

12. How could the impulse transmission be speeded up?

Check your answers by turning to the Appendix, Section 1: Activity 2.



To gain practical experience in understanding nerve pathways, perform the laboratory Reflex Arcs and Reaction Rate found on page 355 and 356 of your text, and then complete the following questions.

Investigation: Reflex Arcs and Reaction Rate

Objective

The purpose of this investigation is to investigate different reflex arcs and reaction rates.

Materials

Refer to the list on page 355 in your text.

Procedure

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

- Knee-jerk: Complete steps 1 to 4.
- Pupillary Reflex: Complete steps 7 and 8.
- Reaction Rate: Complete steps 9 to 11. It should be noted that this portion of the investigation deals with a learned or conditioned reflex. The difference here is the involvement of the brain in determining the response. Because of the extra distance the nerve impulses must travel, conditioned reflexes will be slower than reflex arcs.

Observations

13. Complete Procedure questions a, b, e, f, and g from page 355.

Analysis and Interpretation

14. Complete Application questions 1, 2, and 4 from page 356.

Check your answers by turning to the Appendix, Section 1: Activity 2.

In this activity you have learned about the basic unit of the nervous system and how neurons form circuits. The details of neuron physiology will be the subject of the next activity.

ACTIVITY

3 Nerve Impulse Transmission

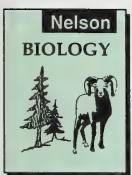


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Electricity has always fascinated humans. An electrical storm is an awesome display of electricity. Have you ever walked across a carpet in hard-soled shoes and received a mild shock when you touched a light switch or door knob? You may have learned a long time ago that this was a form of static electricity similar to lightning but on a much smaller scale. Nerve impulses travel by a similar means to electricity. Does this mean you are an electrically charged organism?

To answer this question, read the section entitled Electrochemical Impulse on pages 356 to 359 in your text. When you have finished reading, answer the following questions.

1. Answer Review questions 7 and 8 on page 364 in your text.
2. Explain the role of the sodium-potassium pumps in establishing a resting potential.

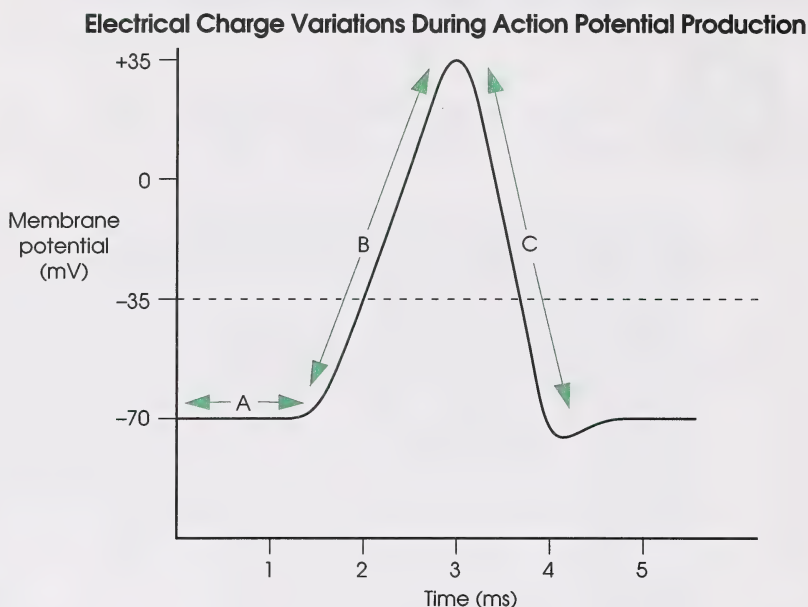


Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

polarity – the electrical charge on the surface of a membrane due to the unequal distribution of ions on either side of the membrane

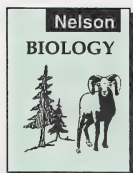
3. The following graph shows the changes in electrical charge in a neuron when an action potential occurs. Identify sections A, B, and C, and describe the state of **polarity** that exists across the membrane in each section.



electrochemical – describes the relationship between the movement of ions and creation of an electrical potential

4. Describe the two forces that move Na^+ from the extracellular fluid (ECF) into the cytoplasm during an action potential.
5. Relate the refractory period to the frequency of nerve impulse transmission.

Check your answers by turning to the Appendix, Section 1: Activity 3.



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

Now that you have learned about the generation of an action potential, you are ready to find out how this **electrochemical** change moves along the neural membrane.

If you are still a bit confused, carefully study Figure 15.10 and Figure 15.11 on page 360 in your text. Imagine a marble rolling along the nerve in Figure 15.11 and knocking the positive charges into the neuron. As the marble passes, the charges come back out again.

Read page 360 and 361 of your text. After you finish reading, answer the following questions.

6. Summarize the effect of an action potential at a specific zone along the membrane.
7. How does the depolarizing region affect adjacent regions of the membrane?

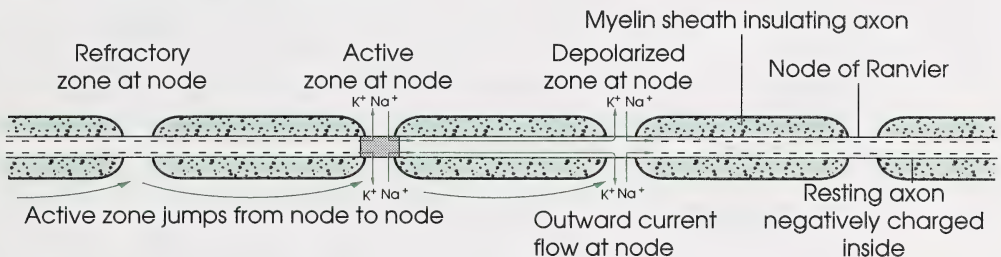
8. Explain why nerve impulses always move along a membrane away from the point of stimulation.
9. Give experimental evidence that supports the hypothesis that neurons have a threshold potential.
10. Distinguish between stimuli below the threshold and stimuli above the threshold and show their relationship to the all-or-none response.
11. Explain the two methods that allow you to detect intensity differences within a variety of stimuli. Carefully study the explanations for Figures 15.12 and 15.13 on page 361 in your text.



Check your answers by turning to the Appendix, Section 1: Activity 3.

Electricity flows when there is an unbroken flow of electrons from one site to another. Nerve impulses will also flow by **continuous conduction** along the membrane of a neuron. The normal rate is about 1 m/s or less!

This transmission rate can be greatly increased by the presence of a myelin sheath. This is shown in the following illustration. Compare this illustration to Figure 15.12 on page 360 in your text.

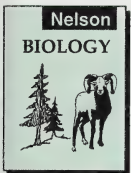


In a myelinated fibre, the action potential moves from node to node, instead of from point to point down the axon. **Saltatory conduction**, as it is known, can increase conduction velocities to 100 m/s or more! This makes it possible for almost instantaneous communication from any part of the human nervous system to any other part.

12. Describe the role of a node of Ranvier.
13. Explain why saltatory conduction in myelinated neurons is so much faster than continuous conduction in unmyelinated neurons.

Check your answers by turning to the Appendix, Section 1: Activity 3.

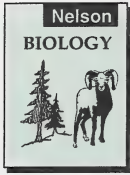
continuous conduction – the transmission of a nerve impulse from one set of gates to the next



saltatory conduction – the transmission of a nerve impulse by jumping from one node of Ranvier to the next

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating



You have learned how nerve impulses are transmitted along a single neuron. What happens when the impulse arrives at the axon terminal and there are no more gates to open?

To learn about how one neuron communicates with the next one, read the section entitled The Synapse on pages 362 to 364 in your text. After you have finished reading, answer the following questions.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

14. Answer Review questions 15, 16, and 17 on page 364 in your text.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Just like electricity, nerve impulses can “jump a gap” and be transmitted along a new cell! Chemical transmitters or neurotransmitters are essential agents in synaptic transmission.

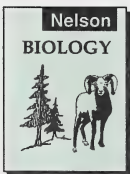
In the next section you will learn about the normal and abnormal distribution of neurotransmitters.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In this section you have learned about the basic unit of the nervous system – the neuron. Its unique structure and condition make it possible for communication to occur.



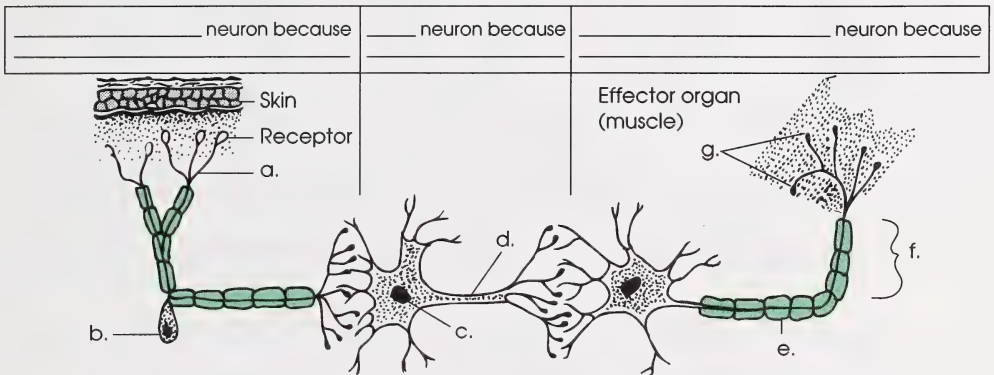
1. For each of the following descriptions, select the term that provides the best match. You may refer to pages 352 to 363 in your text for help.

- _____ an extension of cytoplasm that carries nerve impulses away from dendrites
- _____ the fatty covering over the axon of a nerve cell
- _____ a condition of steady charge difference across the membrane
- _____ a reversal of charge across the membrane and a return to rest

- _____ a change in charge as a result of the influx of Na^+ in a neuron
- _____ the recovery time before a neuron can produce a second impulse
- _____ minimum stimulation to create an action potential
- _____ neurons that carry impulses away from the synapse
- _____ the condition inside a neuron when more K^+ than usual leaves
- _____ the effect produced by an accumulation of chemical transmitters in the synapse

- | | | |
|----------------------|----------------------|------------------------|
| a. action potential | f. myelin sheath | k. resting potential |
| b. axon | g. neurilemma | l. repolarization |
| c. dendrite | h. presynaptic | m. summation |
| d. depolarization | i. postsynaptic | n. threshold potential |
| e. hyperpolarization | j. refractory period | |

2. In the following diagram identify each neuron, explain your reasons for your choices, and label each part of the cells as indicated by the letters.



3. Review Figure 15.5 on page 354 in your text and explain the withdrawal reflex that occurs when the skin is pricked by the pin.

Check your answers by turning to the Appendix, Section 1: Extra Help.

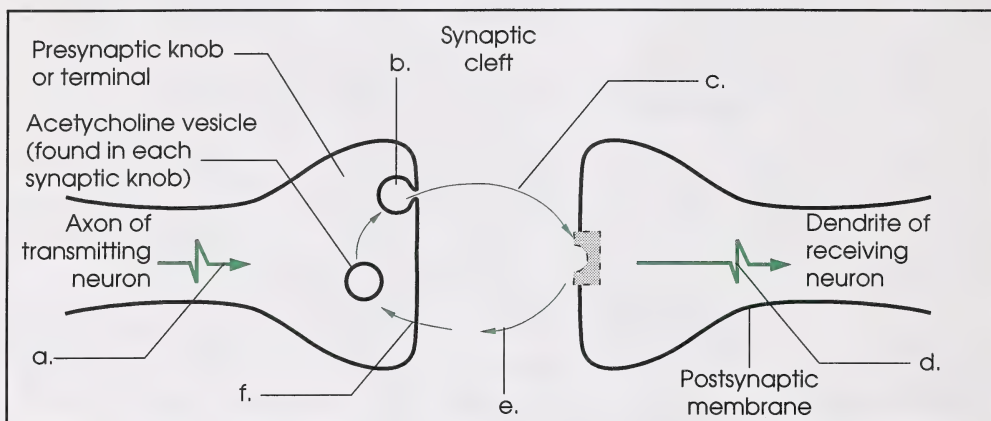
To review nerve impulse generation and transmission, reread pages 356 to 361 in your text and answer the following questions.

4. Do textbook questions 9, 11, 12, and 14 on page 364.

Check your answers by turning to the Appendix, Section 1: Extra Help.

Transmission across a synapse links neurons in special communication pathways like the reflex arcs you have already learned about.

5. Match the events provided with the letters on the label lines. This information summarizes synaptic transmission.



Events

- _____ Acetylcholine is released from vesicles.
- _____ Acetylcholine is resynthesized.
- _____ The postsynaptic action potential is reached.
- _____ Presynaptic action potential arrives at synapse.
- _____ Acetylcholine is inactivated by acetylcholinesterase.
- _____ Acetylcholine binds to a receptor, causing postsynaptic membrane excitation.

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

On pages 377 and 378 there are questions that help you apply the concepts presented in this section. Do one or more of the following:

Textbook question 2, 3, 6, 7, or 8.

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

You have learned that your nervous system is a network of highly specialized cells that are devoted to the detection, transmission, integration, and response to stimuli.

So far this module has introduced you to how information is carried by the system. Next you'll study where the information goes and how it is processed.



Section 1 Assignment: Nervous Communication

Review the Evaluation information found in the introductory pages of this module.

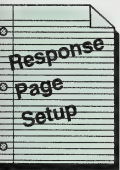
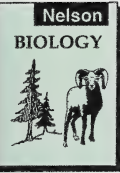
It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 1 Section 1 Assignment Page # Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. Transmission of a nerve impulse depends primarily on the stimulus
 - A. increasing the neuron's permeability to sodium ions and thus allowing these ions to enter the neuron
 - B. decreasing the neuron's permeability to sodium ions and thus allowing these ions to leave the neuron
 - C. increasing the neuron's permeability to potassium ions and thus allowing these ions to enter the neuron
 - D. decreasing the neuron's permeability to potassium ions and thus allowing these ions to leave the neuron



2. A neuron will transmit an impulse when the strength of a stimulus is great enough to reach the
 - A. polarization level
 - B. threshold level
 - C. synapse
 - D. axon

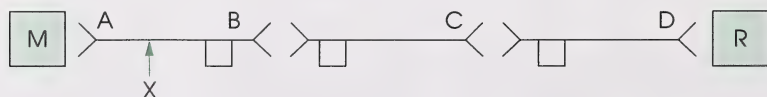
3. Multiple sclerosis is a disease in which the myelin sheaths of neurons degenerate. A person with this disease would have
 - A. an increased rate of diffusion of acetylcholine in synapses
 - B. a decreased rate of diffusion of acetylcholine in synapses
 - C. an increased speed of nerve impulse transmission
 - D. a decreased speed of nerve impulse transmission

4. As the strength of a depolarizing stimulus to an axon is increased,
 - A. the amplitude of action potentials increases
 - B. the duration of action potentials increases
 - C. the speed with which action potentials are conducted increases
 - D. the frequency with which action potentials are produced increases

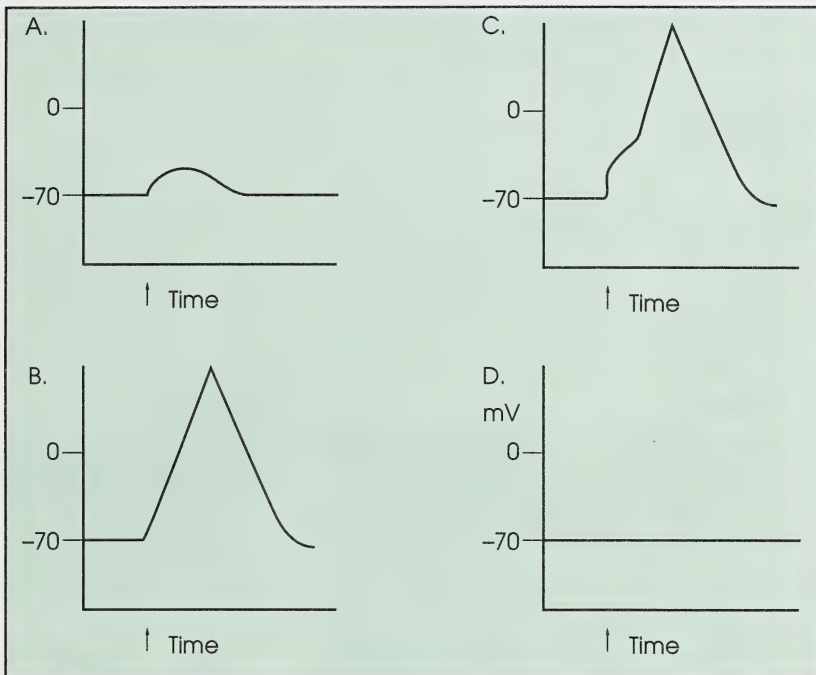
5. Which of the following is **not** a characteristic of action potentials?
 - A. They are produced by voltage-regulated gates.
 - B. They are conducted without a decrease in intensity.
 - C. Na^+ and K^+ gates open at the same time.
 - D. The membrane potential reverses polarity during depolarization.

6. The refractory period of a neuron
 - A. is due to the high negative polarity of the inside of the neuron
 - B. occurs only during the repolarization phase
 - C. occurs only during the depolarization phase
 - D. occurs during depolarization and the repolarization phase

7. The following diagram depicts a typical vertebrate reflex arc involving a single receptor (R), a muscle (M), and three neurons. Assume that you apply an electrical stimulus at Point X. What is the **most distant** point from X at which you would expect to detect a signal?



8. Which of the following is **not** true of the axon in a resting (nonconducting) stage?
- The membrane is relatively impermeable to sodium ions.
 - The membrane has a positive charge on the outside and a negative charge on the inside.
 - The membrane is highly permeable to large negatively charged organic ions and allows them to leak out.
 - Potassium ions are in higher concentration inside the axon than outside.
9. Suppose an intracellular electrode records a resting potential for a given neuron of -70 mV. Which of the following recordings best portrays what you would expect to happen if the cell body of the neuron is given a subthreshold excitatory stimulus? (The arrow indicates the time of stimulation.)



10. What is the correct sequence of these events that follow a threshold potential?
- The membrane becomes depolarized.
 - Sodium channels open and sodium ions diffuse inward.
 - The membrane becomes repolarized.
 - Potassium channels open and potassium ions diffuse outward.
- 3, 2, 4, 1
 - 2, 1, 4, 3
 - 1, 2, 4, 3
 - 4, 1, 3, 2

Use the following information to answer question 11. Present your response in paragraphs that are clearly written and logically organized.

A hockey player has a breakaway. The goaltender moves out to challenge the opposing player, who shoots the puck to the upper right corner of the net. The goaltender immediately flings out an arm to deflect the puck.

The goaltender's eyes serve as receptors for the complex nerve action. Unfortunately, the player scored on the breakaway. The goaltender was too slow!

11. a. Describe the nerve pathway that enabled the goaltender to react to the shot even though he missed it. **(4 marks)**
- b. Provide three examples of technology (procedures, equipment) and explain how each example could be used to improve the goaltender's reflexes. **(4 marks)**

Communication for question 11. **(2 marks)**

Use the following information to answer question 12.

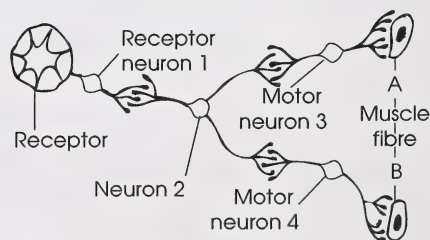
An organism has a system of neurons, each of which has a different threshold of excitation. Any impulse that passes over neurons 3 or 4 also stimulates contraction of their associated muscle fibres. The animal has only one specialized receptor to receive stimuli from the external environment. This receptor is sensitive to the number of units of light energy striking it.

Results I

Stimulus Strength Units	Number of Impulses Initiated in Receptor Neuron per Second
1	—
2	—
3	1
4	2
5	3
6	4
7	5
8	6
9	7
10	8
11	9
12	10

Results II

Neuron Number	Threshold Level in Impulses per Second
2	4
3	6
4	8



12. a. What specific relationship is presented in Results I? **(1 mark)**
- b. What specific relationship is presented in Results II? **(1 mark)**

Science Skills

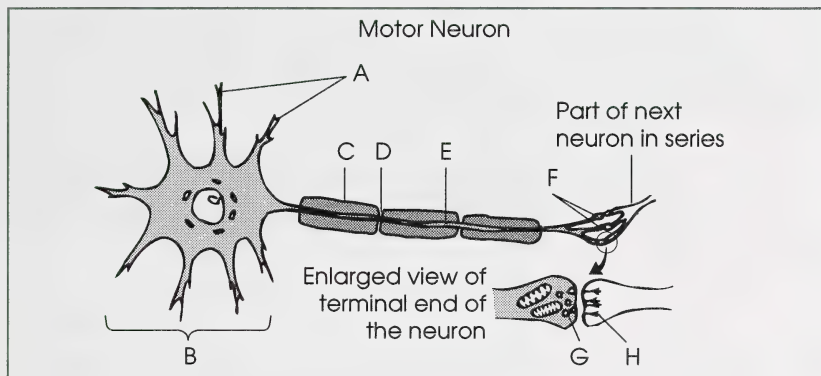
- ☐ A. Initiating
☐ B. Collecting
☒ C. Organizing
☒ D. Analysing
☒ E. Synthesizing
☐ F. Evaluating

- c. Using Results I and II, determine the minimum strength of stimulus necessary to generate a muscle contraction. **(1 mark)**
- d. Explain the effect of seven units of light energy on this system of neurons. **(2 marks)**
- e. If each neuron in the system is myelinated instead of unmyelinated as in the diagram, hypothesize the effect on nerve impulse transmission. **(2 marks)**
- Note:** Remember to explain your answer.

Reproduce the science skills assessment box after your response to this question.
Remember to indicate your evaluation of your skill level for each identified science skill.
Be sure to include the spaces for teacher assessment.

Self: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐
Teacher: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐

Use the following information to answer question 13.



13. a. Describe how structures A and E would differ in a sensory neuron. **(3 marks)**
- b. Identify each structure labelled G and H that is involved in synaptic transmission and give a brief description of their function. **(3 marks)**
- c. Explain the functions of the structure labelled B. **(2 marks)**

Organization and Integration



Have you ever wondered what really goes on inside a computer? How does the information get stored in its memory? Can you delete files without losing the information from the memory? How similar is a computer to your nervous system? How much memory do you have? A reasonable amount would be 5K, 60K, or perhaps 100K. Think about speed for a moment. In a brief instant you can compare a new name to the names of all the people you've ever met.

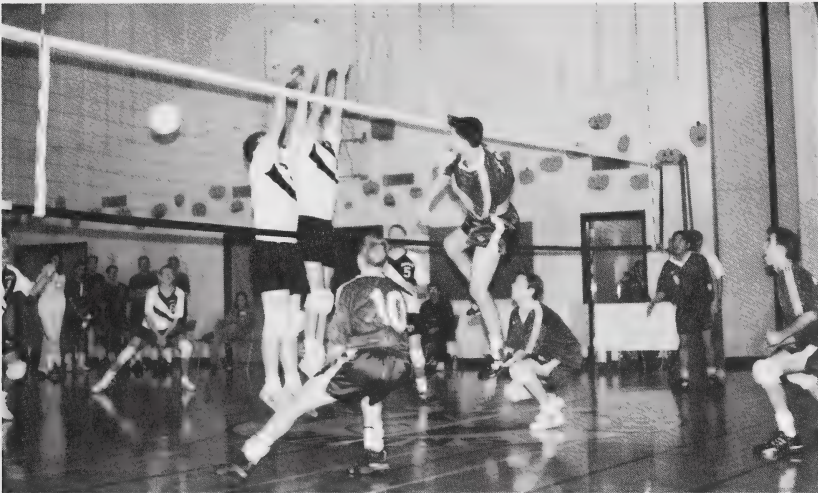
Do you remember studying the respiratory and circulatory systems in Biology 20? If you suddenly have to get up and run to answer the phone, you don't have to think about breathing harder and raising your heart rate. It's automatically controlled from somewhere in your nervous system. And what happens when you sleep? How does your brain and nervous system keep you alive while you drift about in dreamland?

In this section you will learn about the organization of the nervous system. You will also find out how nerve impulses from a variety of stimuli are integrated into normal and abnormal brain activity. Hopefully you'll develop an appreciation for a complex and vital body system that controls everything you do.

ACTIVITY

1 Central and Peripheral Nervous System

A game of volleyball requires good eye-hand coordination. Actually it requires eye, hand, and brain coordination.



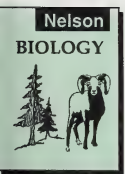
COURTESY OF LOUIS ST. LAURENT HIGH SCHOOL
SMASH VOLLEYBALL TOURNAMENT

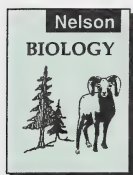
In Section 1 you were introduced to the nervous system, and you learned that special cells called neurons transmit nervous impulses from one area in the body to another. Sometimes the nerve impulse travels from a receptor to the brain. Other times the impulse travels from the brain to an effector such as a muscle or organ.

What happens when these nerve impulses reach the brain? How do responses come from the brain and travel to the correct body area?

Study Figure 15.2 on page 351 in your text. Notice how the nervous system is divided into two major divisions. Read pages 351 to 353 and answer the following questions.

1. What are the two major divisions of the nervous system?
2. What are the two main parts of the central nervous system?
3. What two types of nerves make up the peripheral nervous system?
4. Which nervous system would control an involuntary function like digestion?
5. What type of nerve would conduct a sensation like pain from a sliver in your finger?



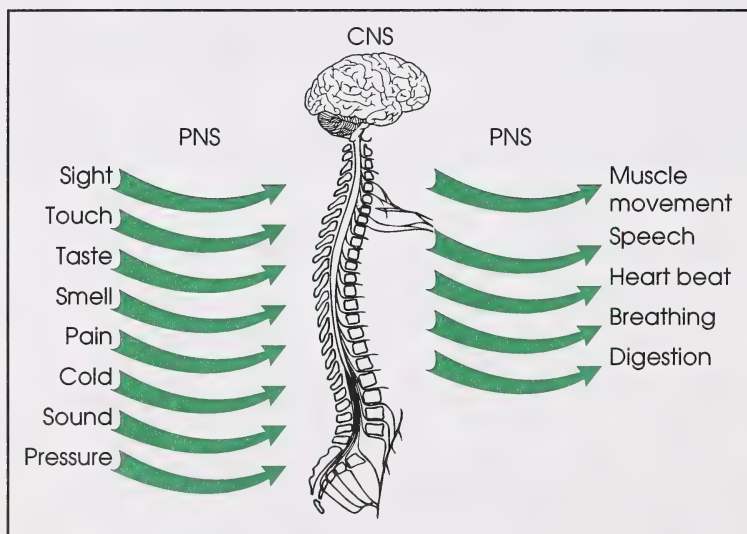


6. Using the terms found in Figure 15.2 on page 351, fill in the blanks for each statement that follows.
- The _____ nerves provide involuntary control of internal organs.
 - The CNS is composed of the _____ and _____. It functions to _____.
 - The _____ nerves provide sensory information about changes in the environment and control _____.
 - The _____ comprises all the cranial and spinal nerves which serve to _____.

Check your answers by turning to the Appendix, Section 2: Activity 1.

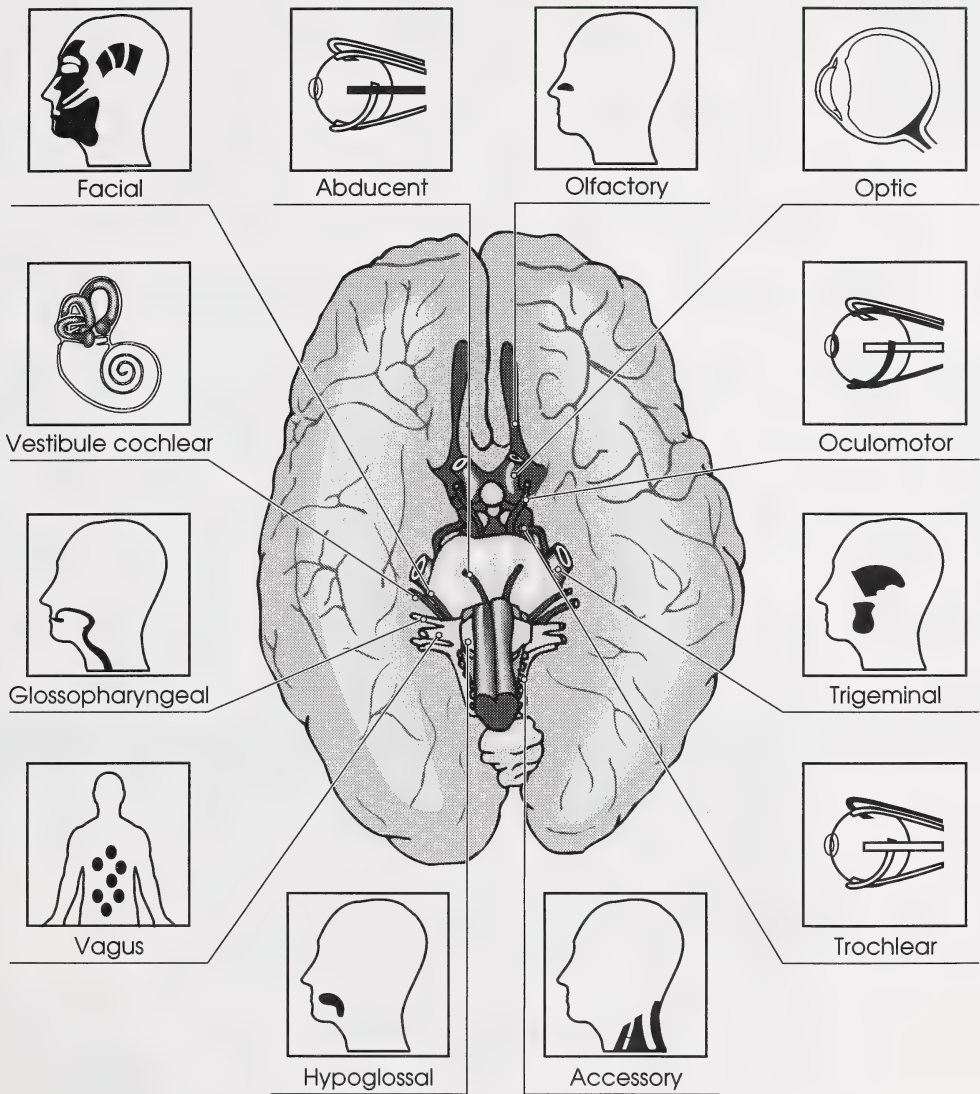
Cranial Nerves and Spinal Nerves

Nerves in the peripheral nervous system carry information from receptors to the CNS or from the CNS to effectors. If this seems complicated, look at the following examples.



Some nerves in the PNS go directly between the brain and particular receptors. These are called **cranial nerves**. These nerves are found at the base of the brain and are not part of the spinal cord. The functions of these nerves may be retained even if the spinal cord is severed, such as in an accident. There are twelve pairs of cranial nerves.

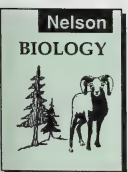
Cranial Nerves

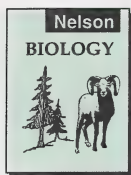


Spinal nerves originate from the spinal cord. These may be sensory or motor nerves.

7. Carefully count the number of pairs of spinal nerves (white) on Figure 15.17 on page 367 in your text.

Read about the autonomic (not automatic) nervous system on page 366. Notice that this is the nervous system that controls your body without you having to think about it. Study Table 15.1 and notice that nerves in this system may speed up or slow down different body functions depending on need. After reading, answer the following questions.





8. Complete the Review questions 18, 19, and 20 on page 375 in your text.
9. Using the information in Table 15.1 on page 366 and Figure 15.17 on page 367 in your text, predict the result of damage to the following nerves.
 - a. vagus nerve
 - b. the second sympathetic nerve
 - c. the fifteenth sympathetic nerve

Ganglia are like fuse boxes where many neurons synapse with one another. Find the dorsal root ganglion in Figure 15.18 on page 368 of your text.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

10. Predict the effect of the following conditions.
 - a. Excess acetylcholine is produced in the sympathetic ganglia.
 - b. Excess norepinephrine is produced in the sympathetic ganglia.
 - c. Excess acetylcholine is produced in the parasympathetic ganglia.
 - d. Excess norepinephrine is produced in parasympathetic ganglia.

physiology – the branch of science dealing with the study of body functions

The central nervous system is probably the most interesting area of human **physiology** because your brain controls all other body functions, even your ability to think.

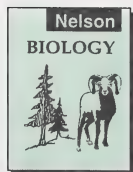
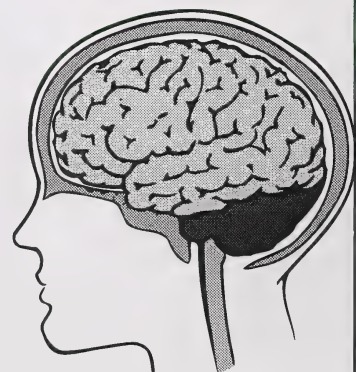
Check your answers by turning to the Appendix, Section 2: Activity 1.

ACTIVITY

2 Studying the Brain

Writers of science fiction have often contemplated such exotic ideas as brain transplants and brains living outside the body.

Today science and technology make some of these ideas actually possible. Brain cells can be kept alive in cultures and they may even divide. Read about brain research in Canada on pages 365 and 373 in your text.



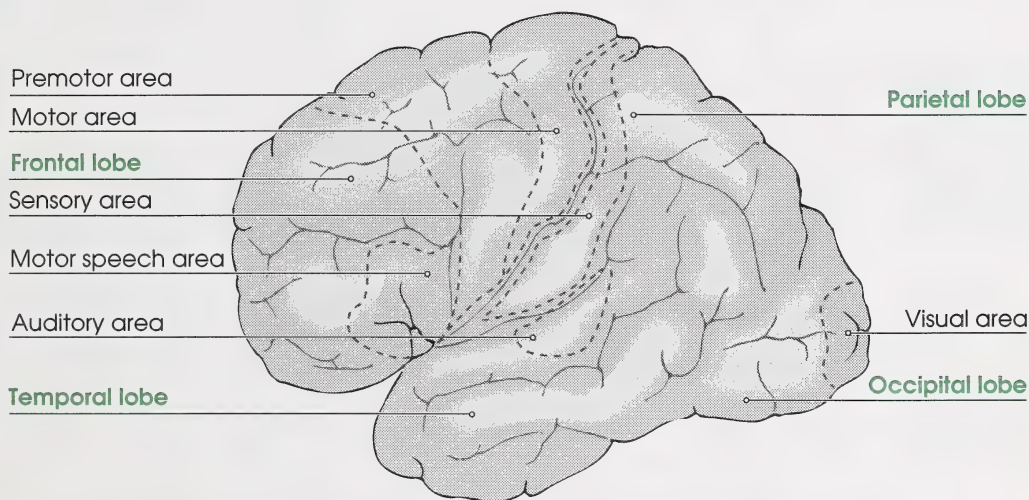
So what is it about the brain that makes it so special? Read pages 369 to 371 in your text to gain an appreciation for the complexity of the human brain. Compare the brains in Figure 15.19 to the brain in Figure 15.20.

1. Which area of the brain is getting larger as you compare the brains?
2. Describe the functions of this area.
3. What area of the brain forms the surface of the cerebrum?
4. Without increasing the volume of the brain, how are the number of cells in the cerebral cortex increased?

The cerebrum or forebrain can be divided into four functional areas or lobes.

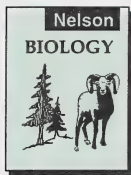
5. Name the four lobes and extract a two- or three-word function from Table 15.2 on page 370 in your text.

Using the following diagram and Figure 15.21 on page 372 in your text, answer the questions that follow.



6. a. Which lobe controls speech?
- b. Which lobe controls vision?
- c. Describe the lobes and areas used to snap your fingers loudly.

Check your answers by turning to the Appendix, Section 2: Activity 2.



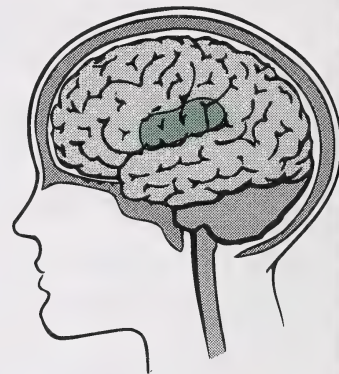
Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

meningitis – a bacterial disease in which inflammation of the meninges occurs

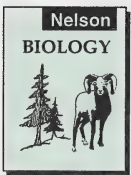
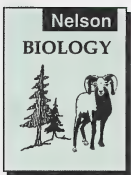
Carefully review pages 367 to 372 in your text and answer the following general questions on the central nervous system.

7. Complete Review questions 21, 22, and 23 on page 375 in your text.
8. Explain how paralysis or loss of motor control of the legs can occur without a loss of sensation.
9. Based on the location and function of the meninges, draw conclusions on the effects of **meningitis**.
10. If you were involved in a terrible car accident and suffered damage to the highlighted surface areas of the brain shown in the diagram on the right, what changes would probably occur in your normal cerebral activity?



Read the Case Study on page 374 in your text to gain an appreciation of the part of the brain that controls personality.

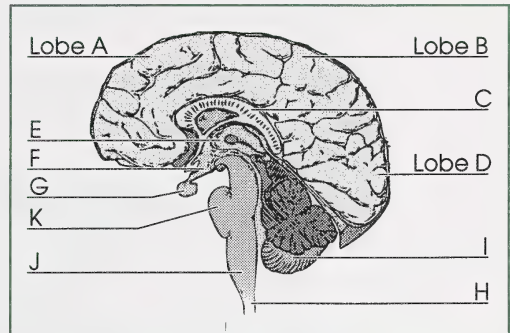
Check your answers by turning to the Appendix, Section 2: Activity 2.



So far you've been studying the functions of the forebrain or cerebrum. Go back and notice the four other areas in Figure 15.20 on page 370. One area, the midbrain, is coloured (orange) but not labelled. The pituitary, which is also a gland, is identified on the diagram. If you carefully compare the diagram to the photograph on page 370, you may notice that in the photo, the pituitary gland is missing. It may have been lost in preparation of the specimen.

11. a. What body functions are controlled by the medulla oblongata?
- b. Describe the location and function of the pons.
- c. What area of the brain controls balance and coordination?

12. Examine the diagram showing the major structures of the brain. Construct a chart that identifies each labelled structure and its function as a summary for this activity.



Check your answers by turning to the Appendix, Section 2: Activity 2.

Think about this for a moment. Your brain enables you to know that you exist. Deterioration of brain areas associated with diseases such as Alzheimer's or Parkinson's can result in loss of that awareness and a serious change in the quality of life. Evidence indicates that drug use, particularly cocaine, during pregnancy can have a serious effect on brain development of the fetus. Have you heard of "crack babies" or fetal alcohol syndrome (FAS)? In some cases the development of the forebrain does not occur and instead is replaced by a watery fluid (hydrocephaly). The midbrain and hindbrain do develop and a baby can be born with basic bodily functions such as breathing and heart beat but no chance whatsoever of consciousness. Appreciate your brain and nervous system as you continue your studies.

ACTIVITY

3

Looking at the Brain and Nervous System

Much of what is known about the brain and nervous system has been learned by studying their functions.

View the video *Nervous System* which explains how the nervous system connects the human body to its external environment.

Familiarize yourself with the following questions first. Then as you view the video, answer the questions. Stop the tape whenever necessary.

1. What is the function of the nervous system?
2. Describe the basic organization of the nervous system.



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

- Outline the sensory input to Sharon's brain as she takes the peach out of the picnic basket.
- Complete the following chart that relates sensory receptors to the site of interpretation.

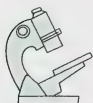
Sensory Receptor	Cerebral Cortex Lobe
olfactory cells	
	occipital
hair cells in ear	
	frontal

- Describe the comparison between Jim's brain and a computer.
- Compare the involuntary control of the autonomic nervous system and the cerebellum.

Check your answers by turning to the Appendix, Section 2: Activity 3.

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating



Investigation: Central Nervous System

Objective

In this investigation you will observe photomicrographs of parts of the CNS.

Materials

- microslide viewer
- microslide set 69, The Central Nervous System

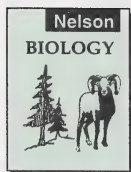
Procedure

- Observe slides 1 through 7 and read each description. Then answer the following questions. Carefully place the microslide strip back in its folder when you have finished answering the questions.

Observations

By carefully observing Slide 1, you can see a thin layer covering the inside of the retina (R). Notice how this layer forms the optic nerve (N) which leaves the eye. (You'll study the eye in greater detail in Section 3.)

You may compare this slide to diagrams on page 384 to 385 in your text.



7. Speculate as to what this thin layer is composed of.

By comparing Slide 1 to Slide 2, you can appreciate the complexity of the structures of the retina.

8. What letter on Slide 2 identifies the inner layer of the retina which contains the neurons that carry an impulse to the optic nerve?
9. Draw a diagram of slides 4 and 7. Identify the following parts by labelling the Slide 4 sketch: bone, canal, grey matter, and white matter. Identify and label a bundle of axons and a blood vessel on your Slide 7 sketch.

Analysis and Interpretation

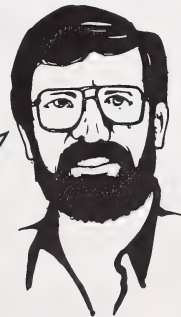
10. Differentiate between the CNS and the PNS.
11. Complete the following chart that relates structures and functions.

Structure	Function
cerebrum	
cerebellum	
medulla	
grey matter	
nerve	

Check your answers by turning to the Appendix, Section 2: Activity 3.

The brain is divided into two hemispheres. Since each hemisphere controls the functions of the opposite side of the body, you will better understand this attempt at humour.

"Left-handed people are the only ones in their right minds!"



ACTIVITY

4

Chemicals and the Brain

Why do pharmaceutical companies enjoy big profits from the sale of prescription drugs? Why is the use of nonprescription drugs increasing at an alarming rate? Why do humans take drugs anyway?



These are hard questions to answer because there are so many chemicals and just as many reasons to take them. Perhaps some answers can be found if you look at yourself as a chemical factory. You learned in Section 1 that nerve cells communicate with each other by producing and releasing **neurotransmitters**. Review information on page 362 and 363 of your text.

neurotransmitter

— a chemical substance secreted by an axon terminal that stimulates another neuron or muscle

1. Which part of the neuron releases these chemicals?
2. What is the effect of neurotransmitters?
3. How is this effect regulated?
4. What would happen if acetylcholine was released into a **neuromuscular junction**?

neuromuscular junction

— the space between the axon terminal of a motor neuron and a muscle fibre

Check your answers by turning to the Appendix, Section 2: Activity 4.

Nelson

BIOLOGY

Read Natural and Artificial Painkillers on page 375 in your text. After reading, answer the following questions.

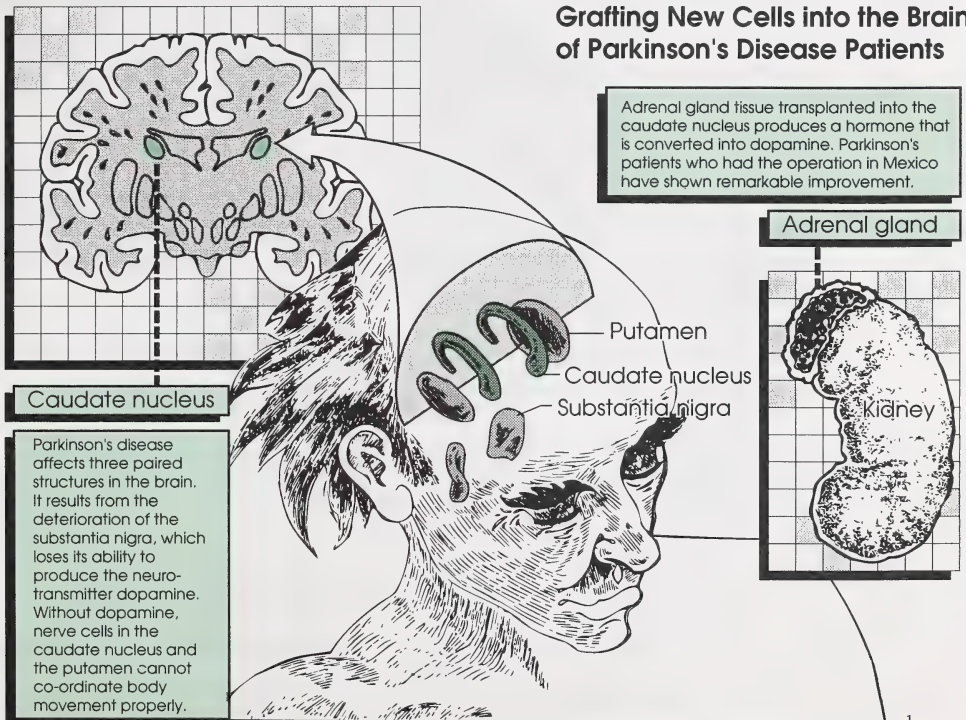
5. How do endorphins work?
6. Explain how the opiates are able to mimic the effect of endorphins.
7. Describe the relationship that exists between the use of opiates and their abuse.
8. Devise a logical explanation for an addiction to alcohol.
9. Identify the effect of **anaesthetics** keeping in mind that historically alcohol has been used as an anaesthetic.

anaesthetic – a substance that produces a loss of sensation

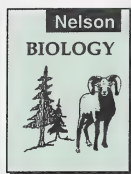
Check your answers by turning to the Appendix, Section 2: Activity 4.

Have you ever noticed someone with hand tremors? Maybe you have also seen someone experience periods of frozen movement or stiffness. These are some of the symptoms of a major disease that results from a chemical disorder in the brain called Parkinson's disease.

Grafting New Cells into the Brain of Parkinson's Disease Patients



¹ The Edmonton Journal for the News Bulletin, June 22, 1987. Reprinted by permission of The Edmonton Journal.



Use the information on Parkinson's disease found in the previous graphic and on pages 364, 375, and 378 of your text to answer the following questions.

10. Explain the symptoms of Parkinson's disease if dopamine is generally a synaptic inhibitor.
11. How does the transplant of adrenal gland tissue help to eliminate the symptoms of the disease?

Huntington's disease is very similar to Parkinson's. It is believed to be caused by the loss of GABA – secreting cells in certain parts of the brain called the caudate nucleus and putamen.

12. Explain how these diseases may be related.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Follow-up Activities

If you had difficulty understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In this section you have learned about the organization of the nervous system. There has been an emphasis on the chemical communication between neurons – an integration of stimulating and inhibiting pathways. You also learned that disease can disrupt the normal balance leading to abnormal responses.

1. For each of the following descriptions, select the term that provides the best match.

- | | | |
|--------------------|----------------------|----------------|
| a. autonomic | f. medulla oblongata | k. pons |
| b. cerebellum | g. meninges | l. sympathetic |
| c. cerebral cortex | h. occipital | m. somatic |
| d. corpus callosum | i. parasympathetic | n. temporal |
| e. frontal | j. parietal | |

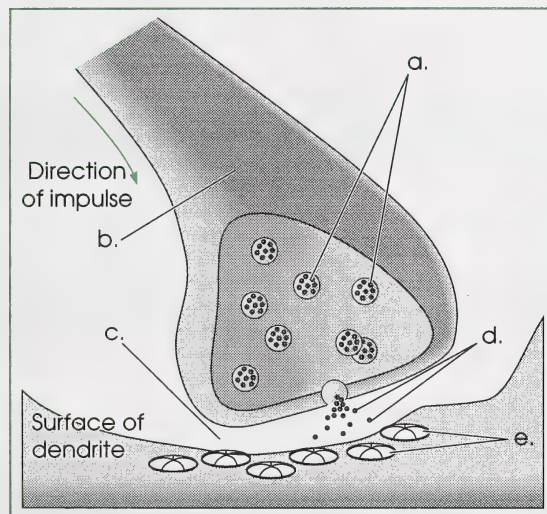
_____ involuntary nerves designed to maintain homeostasis

_____ involuntary motor nerves that prepare the body to respond to stress

_____ protective membranes that surround the brain and spinal cord

- _____ outer, grey-matter lining of the cerebral hemispheres
- _____ lobe of the cerebrum associated with intellectual activity and personality
- _____ lobe of the cerebrum associated with memory and interpretation of sensations
- _____ lobe of the cerebrum associated with touch, temperature, and speech
- _____ lobe of the cerebrum associated with vision
- _____ region of the brain that coordinates muscle movement
- _____ region of the brain that joins the spinal cord with the cerebellum

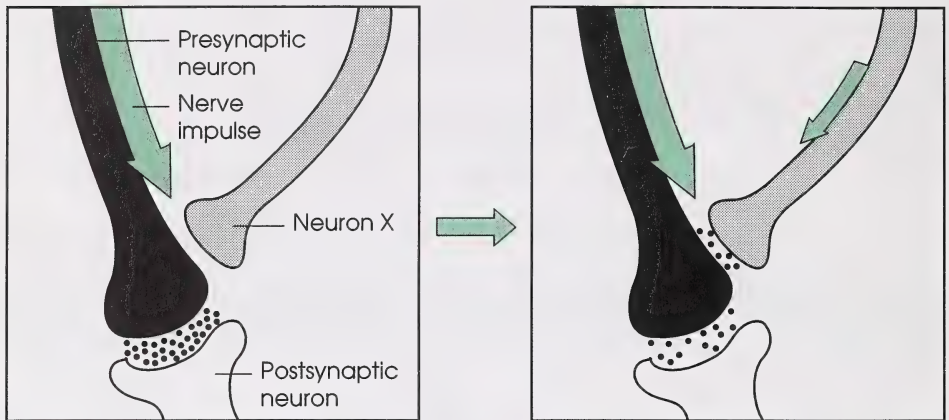
2. Using the following diagram of a synapse, complete the chart with the appropriate terms and functions. Try to complete the chart first without referring to your notes or text.



Label	Structure Name	Function
a.		
b.		
c.		
d.		
e.		

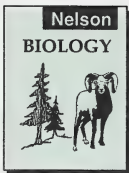
3. Distinguish between chemical transmitters that inhibit and ones that stimulate.

4. The following diagram illustrates the effect of transmitters. In the frame on the left, Neuron X is inactive and does not affect the release of transmitters from the presynaptic neuron. In the frame on the right, Neuron X releases its chemical transmitters and alters the activity of the presynaptic neuron. From what you see, explain why it is logical to conclude that Neuron X releases transmitters that inhibit.



Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment



On pages 378 and 379 of your text there are critical-thinking questions that will interest you after learning about the organization and integration in the nervous system. Do one or more of the following:

Textbook question 1, 2, 3, 4, 5, and 6

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

You've learned in this section that the nervous system is organized into functional areas that receive, integrate, and send information. At the centre of the system is your brain. Connecting the brain to the rest of the body is an elaborate system of nerves organized according to specific purposes. Continue your study of the nervous system in Section 3 and keep in mind how much you depend on this system for everything you do.

Section 2 Assignment: Organization and Integration

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 1 Section 2 Assignment Page # Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. The primary motor areas of the brain are located in the
 - A. parietal lobe
 - B. frontal lobe
 - C. temporal lobe
 - D. occipital lobe

2. Grey matter of the spinal cord is mostly composed of
 - A. cerebrospinal fluid
 - B. interneurons
 - C. unmyelinated axons
 - D. myelin

3. Which of the following structures or regions is **incorrectly** paired with its function?
 - A. medulla oblongata – coordination of basic metabolic functions
 - B. cerebellum – unconscious coordination of movement and balance
 - C. corpus callosum – discrimination of sound
 - D. hypothalamus – production of hormones and regulation of temperature, hunger, and thirst

4. A certain neuron in a cat is located entirely outside the central nervous system. The synaptic vesicles of its axon release a transmitter substance that is not destroyed by cholinesterase. This neuron is
 - A. a sensory neuron of the somatic (voluntary) portion of the nervous system
 - B. a first motor neuron of the sympathetic system
 - C. a second motor neuron of the sympathetic system
 - D. a first motor neuron of the parasympathetic system

5. The sympathetic nervous system would likely be most active while a person is
- A. running a race
 - B. digesting a large meal
 - C. sleeping in the afternoon
 - D. recovering from an illness

Use the following information to answer question 6.

Neurotransmitters of the Autonomic Nervous System

Parasympathetic postganglionic axons secrete **acetylcholine** into synapses. Acetylcholine is rapidly decomposed by an enzyme in synapses. Most sympathetic postganglionic axons secrete **norepinephrine** (noradrenaline) into synapses. Most of the norepinephrine released by neurons is reabsorbed into nerve endings by active transport. Norepinephrine reabsorption may take a few seconds during which time some molecules may enter the blood and remain active until they diffuse into tissues containing decomposing enzymes.

6. Based on this information, which prediction can be made about the different actions of the two regulatory mechanisms?
- A. Acetylcholine produces a more prolonged effect than norepinephrine.
 - B. Norepinephrine produces a more prolonged effect than acetylcholine.
 - C. Parasympathetic fibres transmit impulses faster than sympathetic fibres.
 - D. More energy is required to reabsorb acetylcholine molecules than to reabsorb norepinephrine.
7. The ability to pick up a pin from a table requires fine motor co-ordination that involves which two areas of the brain?
- A. cerebellum and medulla oblongata
 - B. cerebrum and medulla oblongata
 - C. cerebrum and hypothalamus
 - D. cerebellum and cerebrum
8. One difference between the somatic and autonomic systems is that
- A. the autonomic system stimulates the contraction of smooth muscle whereas the somatic system stimulates the contraction of skeletal muscle
 - B. acetylcholine is a neurotransmitter only in the somatic system
 - C. the somatic system has myelinated neurons whereas the autonomic system does not
 - D. the motor neurons of the autonomic system exit only from the brain and those of the somatic system only from the spinal cord

9. Which one of the following groups of structures are the major regions of the hindbrain?
- cerebellum, thalamus, pons
 - cerebellum, pons, medulla oblongata
 - thalamus, pons, medulla oblongata
 - cerebrum, thalamus, medulla oblongata

Use the following information to answer question 10.

Ataxia is a condition characterized by an inability to coordinate the speed, force, and direction of muscle movement. The movements of a person suffering from ataxia may resemble those of a drunken person. The person may reach for an object and miss it by placing the hand too far to the left or right and then attempt to compensate by moving the hand in the wrong direction.

10. A person suffering from ataxia would probably have damage to the
- parasympathetic nerves
 - medulla oblongata
 - hypothalamus
 - cerebellum

Use the following diagram and information to answer question 11.

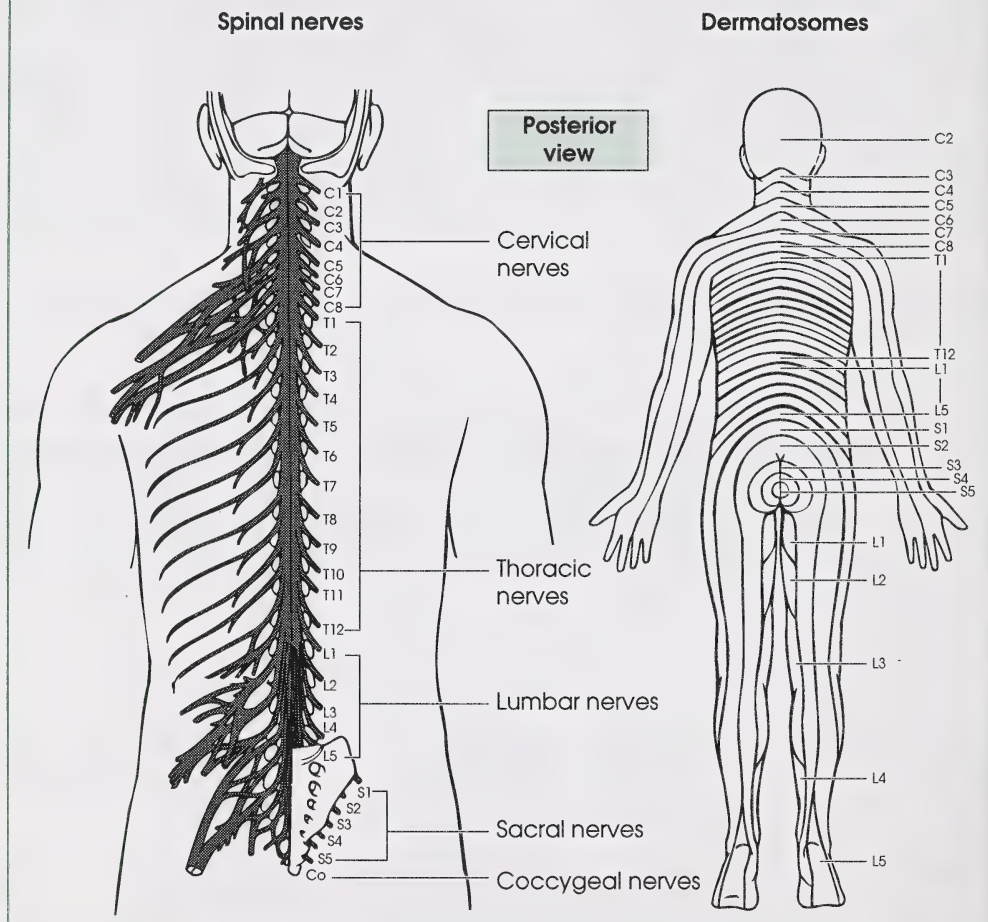
Some Physiological Effects Caused by Autonomic Nervous System Stimulation						
Subject	Adrenal Glands	Thyroid Gland	Peristalsis of Digestive Tract	Pupils of the Eyes	Bronchioles	Heart Rate (beats/min)
1	–	–	+	–	–	70
2	+	+	+	+	+	90
3	+	+	–	–	–	95
4	–	+	–	–	–	75
+ indicates relatively active – indicates relatively inactive				+ indicates dilated – indicates constricted		

11. a. Based on your knowledge of the effects of the autonomic nervous system, which of the subjects appears to be the most relaxed? **(1 mark)**
- b. Support your choice by explaining how the activity level indicated in any four of the six columns in the chart suggests a relaxed state. Link your answer to sympathetic or parasympathetic function. **(4 marks)**

Use the following information to answer question 12.

Spinal nerve injuries occur in a variety of ways including birth injuries, dislocations and fractures of vertebrae, stabs, gunshot wounds, and pressure from tumours in surrounding tissues.

Dermatomes are areas of the skin where a group of sensory nerve fibres lead to a particular dorsal root. They are highly organized, but vary considerably in size and shape. A map of these dermatomes has been created by experimentation and can be used in localizing the sites of spinal nerve injuries.



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

12. a. What relationship exists between spinal nerves and dermatomes? (1 mark)
- b. Predict the effect of severing the dorsal root of spinal nerve C7. (1 mark)
- c. Explain what type of spinal nerve damage may lead you to experience a loss of sensation from your outer left leg. (2 marks)

- d. Describe the organization and functions of spinal nerve, T12. (3 marks)

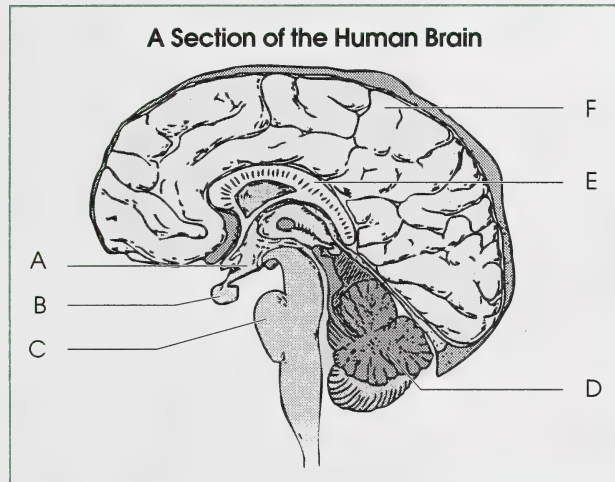
Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐
Teacher: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐

13. Provide two examples of technology (procedures, equipment) and explain how each example could be used to protect the central nervous system. (2 marks)

Communication: (2 marks)

Use the following information to answer question 14.



14. Choose four of the labelled structures. Identify each of your choices by name and describe the specific role of each part in the function of the central nervous system. (4 marks)

Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐
Teacher: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

Sensing the Environment



COURTESY OF WEST EDMONTON MALL

Can you imagine yourself riding on this rollercoaster? Try it; just close your eyes. Do you see the track in front of you? Can you hear the screams? Do you feel your stomach turning? If you have experienced the thrill of such a ride, then you have had an introduction to your sensory systems.

In this section you will learn that your body detects motion, pressure, light, and sound. Stimuli from your external environment are detected, converted to nerve impulses, transmitted, and integrated, all before responses are coordinated. Responding to stimuli makes life exciting.

ACTIVITY

1 Tactile Sensations

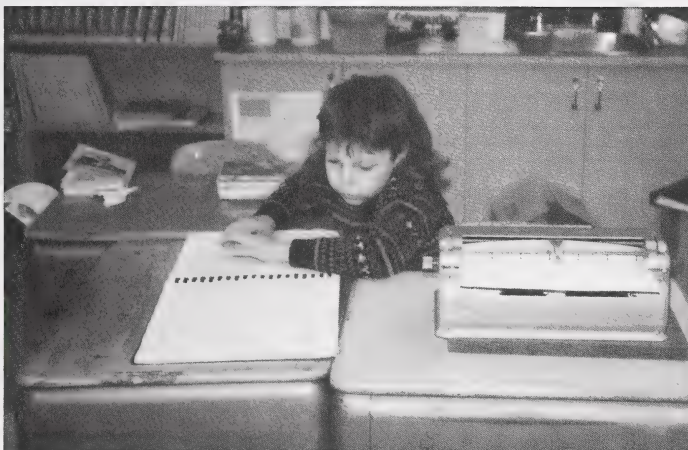
Humans are highly sensitive animals. If your nose is tickled with a feather, you sneeze. Step on a tack and your foot seems to jerk away even before you feel it. Is your body under your control, or is it under its own control with you as just a spectator?

To learn about the detection of stimuli generally and the **tactile** senses specifically, read pages 380 to 382 in your text. After reading, answer the following questions on page 384 in your text.

1. Complete Review questions 1, 2, and 3.

Check your answers by turning to the Appendix, Section 3: Activity 1.

Although receptors may vary in their individual characteristics, they all generate nerve impulses in sensory neurons. One major group of receptors is found in the skin and is associated with the **somatic senses** of touch, pressure, temperature, and pain. The ability to read Braille requires high tactile sensitivity – and practice.



Investigation: Somatic Sense Receptors

Objective

In this investigation you will observe photomicrographs of two receptors.

Background Information

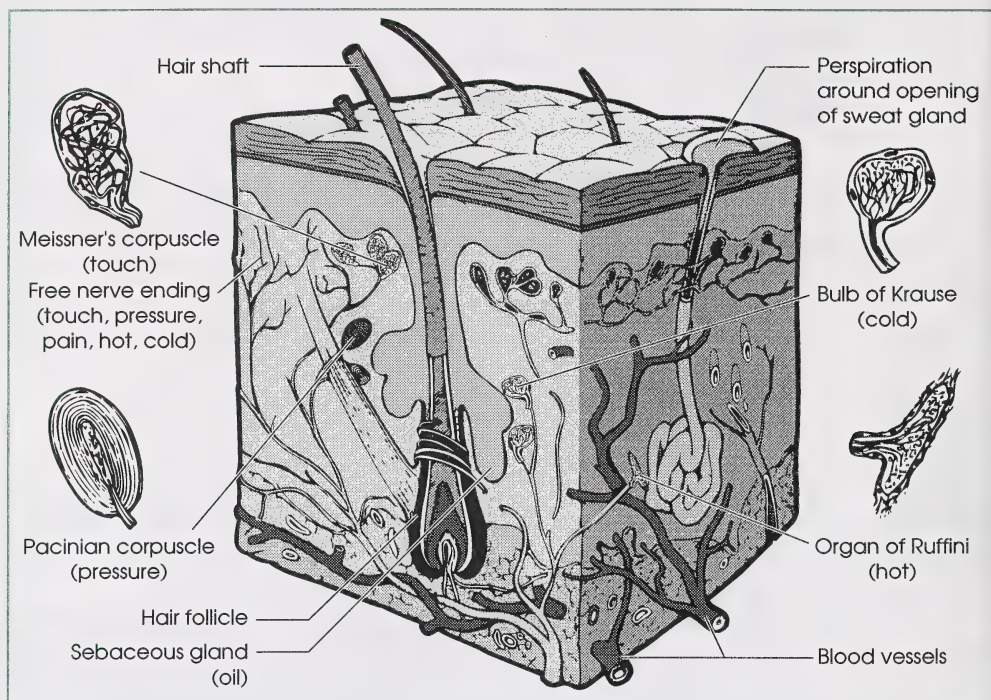
The following schematic diagram shows a section of skin with its receptors, hair, and blood vessels.

tactile – relating to the sense of touch

Nelson
BIOLOGY

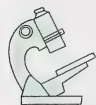


somatic senses – involving receptors associated with skin, muscles, joints, and internal organs



encapsulate – to
enclose or wrap
as in a capsule

Primary receptor cells are the free nerve endings because the sensory neurons can be directly stimulated. Secondary receptor cells **encapsulate** or synapse with sensory neurons. Meissner's and Pacinian corpuscles, as well as the Bulb of Krause and Organ of Ruffini, are examples of these secondary receptor cells. Notice their particular sensitivities on this diagram.



Materials

- microslide viewer
- microslide set 99, The Senses

Procedure

Read the information at the beginning of the folder for a perspective on the sensory system and brain. Carefully read the descriptions before viewing each microslide.

- Observe Slide 1 of the Pacinian corpuscle.
- Observe Slide 2 of the Meissner's corpuscle and free nerve ending.

Observations

2. Draw a diagram of each of the three receptor cells observed. Identify each receptor and its sensory neuron with appropriate labels.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Analysis and Interpretation

3. Explain why the free nerve ending is a primary receptor and the corpuscles are secondary receptors.
4. Compare the location of these receptors in the skin using the diagram in the Background Information and infer the different sensations of pressure generated by each receptor.

Check your answers by turning to the Appendix, Section 3: Activity 1.

Now that you have learned about the structure of your touch or pressure receptors, you are ready to investigate the distribution of these receptors in your skin.

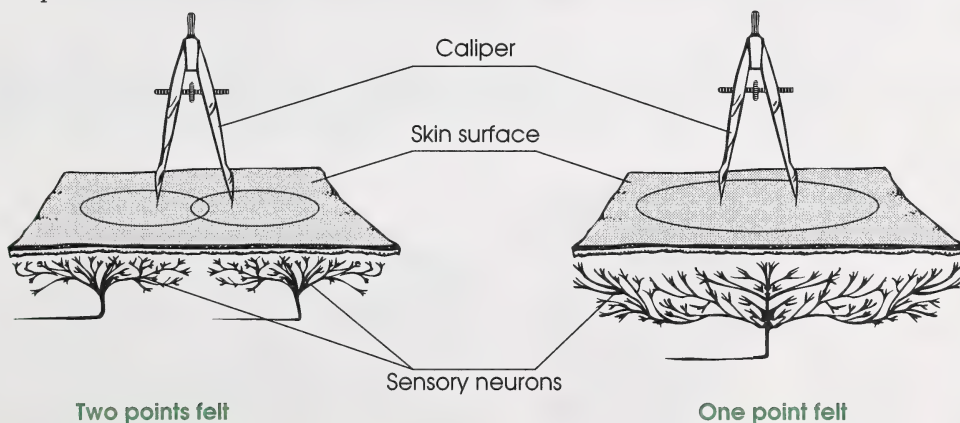
Investigation: Two-Point Touch Threshold

Objective

In this investigation you will design and perform an experiment to test the relationship between the receptive field area for touch receptors and different areas of your skin.

Background Information

Each sensory neuron of your skin is sensitive to stimuli within a certain area. This area varies inversely with the density of receptors in the region. That means you will have touch receptors with small **receptive field** areas where the density of receptors is the greatest. The regions with the lowest density will have receptors with the largest receptive fields.



The sensitivity of each region can easily be determined by whether one point or two points is felt. This is called the two-point touch threshold.

Science Skills

- ☒ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

receptive field – the surface area whose stimulation results in the generation of nerve impulses in a sensory neuron

Procedure

5. Identify the manipulated variable and responding variable in this experiment.
6. Write a problem statement.
7. Produce an hypothesis for your problem statement.
8. Design and perform an experiment to test your hypothesis. Remember to list your materials and a step-by-step procedure. To obtain the best results, you should use at least six different areas of your body to test. Using one subject will be sufficient, but a larger test sample would be better.

Check your answers by turning to the Appendix, Section 3: Activity 1.

Observations

9. Record your results in a suitable chart.

Analysis and Interpretation

10. Based on the data you obtained, create a bar graph to present your results.
11. Evaluate your hypothesis by making an inference for your experiment.
12. Explain how the sensitivity of the skin is related to the density of receptive fields in different regions of the body.

Check your answers by turning to the Appendix, Section 3: Activity 1.



In this activity you have learned about some of the somatic senses. The next two activities will teach you about two important special senses – visual and auditory.

ACTIVITY

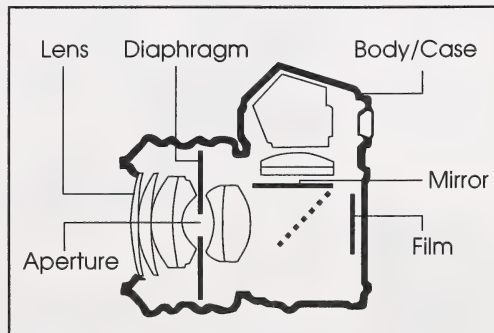
2 Visual Sensations

Your eyes are like the oceans – not because they might be blue, but because 70% of the Earth's surface is water and 70% of the sensations the body receives are visual. So sensing your environment is dominated by vision.



To learn about the structure of the eye, read pages 384 to 386 in your text. After you have finished reading, answer the following questions.

1. Complete Review questions 6 and 7 on page 393 in your text.
2. Complete the following chart which relates the human eye to a camera. You may read page 388 for clues.



Nelson
BIOLOGY

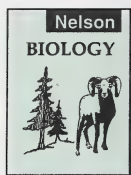


Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

Camera Part	Function in Camera	Part of the Eye
body/case	supports and protects the film	
lens	focuses the image on the film	
diaphragm	regulates the amount of light entering	
aperture	functions as the hole to allow light in	
film	contains photosensitive chemicals	

- Owl and cat eyes have a reflective inner choroid layer that is not present in humans. Explain the advantage these animals have over humans seeing at night.
- Using Figure 16.6 on page 385 in your text, trace the pathway for the stimulus of incoming light to the nerve impulses in the brain.



Check your answers by turning to the Appendix, Section 3: Activity 2.

Picture yourself in a park on a beautiful summer day. How can you see something that is not really there? You simply remember the images you once saw with your eyes. To learn about vision and how your brain “sees,” read pages 388 to 392 in your text. After reading, answer the following questions.

- Complete Review questions 8, 9, 10, 11, 12, 13, and 14 on page 393 in your text.

Check your answers by turning to the Appendix, Section 3: Activity 2.

To gain practical experience in understanding vision, perform the laboratory Vision as found on pages 394 and 395 in your text.

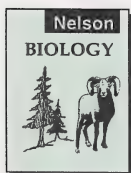
Investigation: Vision

Objective

The objective of this investigation is to investigate different aspects of vision.

Materials

Refer to the materials list on page 395 of your text. A Snellen Eye Chart is reproduced in the Appendix. Tear out the sheets and assemble the chart according to directions.



Procedure

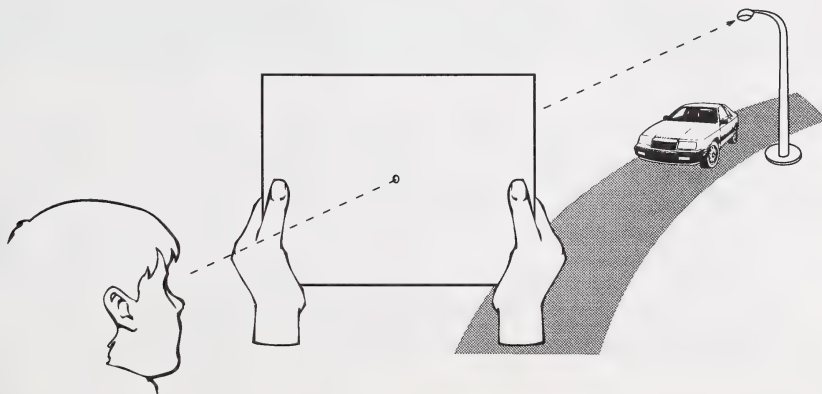
- Visual acuity is a measure of how clearly you see a distant object. Complete steps 1 and 2. If you normally wear glasses, complete the steps without them.
- Your blind spot is an area on your retina where no vision is generated. You can investigate the blind spot in each eye by completing steps 3 and 4. A small change in the textbook procedure is necessary.

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

To find the blind spot in your left eye, close your right eye and stare at the **spot** on page 394 while holding the text about 30 cm from your face. Move the spot slowly towards your left eye. Watch for the cross to suddenly disappear. It may happen around 12 to 15 cm. Now find the blind spot for your right eye. Close your left eye; stare at the **cross** with your right eye. Start with the book about 30 cm from your face and move it closer. While staring at the cross, watch for the spot to disappear. This procedure can take a little practice. You may even wish to draw two (5 mm) spots about 5 cm apart on a piece of paper. Hold the paper about 15 cm in front of your face. Close one eye and stare at each spot in turn. Repeat the procedure with your left eye.

- Dominant eye refers to one eye that seems to capture more of your attention than the other. Generally, right-handed people have a right dominant eye and vice versa. The procedure in the text works but there are several variations. Make a 5 mm hole in the center of a piece of writing paper. With both eyes open, stare through the hole at a distant object. Start by holding the paper at arms length. Now move the paper towards your face while staring through the hole at the object. The hole in the paper will travel to your dominant eye.



stereoscopic – two slightly opposed views that create a three-dimensional effect or a sense of depth

- **Stereoscopic** vision is important to organisms that rely on a good judge of distance, such as humans, owls, and cats. Investigate your stereoscopic vision by completing steps 8 to 14.



Observations

6. Complete Procedure questions a to k from pages 394 and 395 in your text.

Analysis and Interpretation

7. Answer Application questions 2 to 5 on page 395 in your text.
8. How does the lens of a camera focus compared to the lens of an eye?

Check your answers by turning to the Appendix, Section 3: Activity 2.

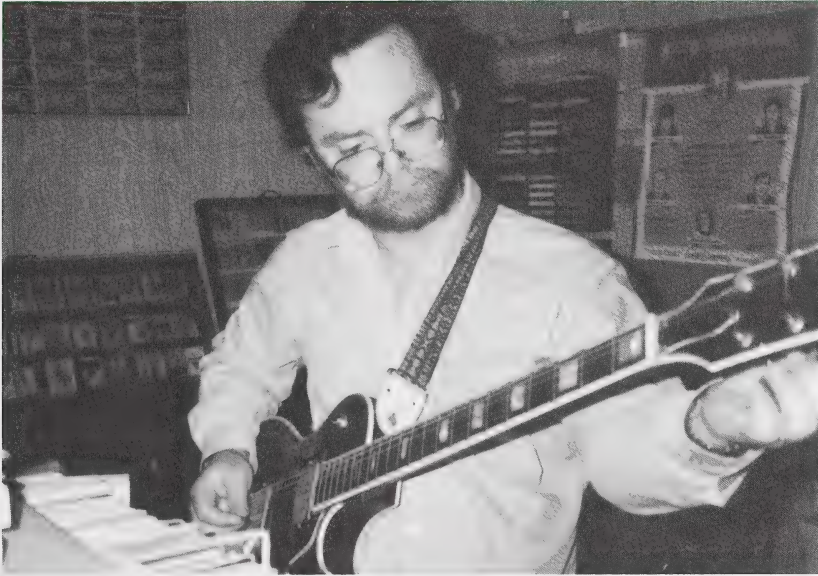
Look at this illustration. What do you see? The wife/mother-in-law illusion can be seen either as an attractive woman wearing a fur, whose head is turned away to her right or as a gnarled old woman looking down to the left.

The photoreceptors relay visual stimuli along nerve pathways to the brain, but what you see or perceive is a result of the integration of past and present knowledge in your brain.



ACTIVITY

3 Auditory Sensations



COURTESY OF DAVE BELL

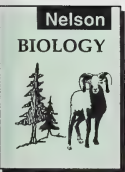
Do you have a favourite type of music or favourite instrument? Can you recognize some of your friends by the sound of their voice? What are your favourite recreational sounds, birds singing or skates on ice? These perceptions of your world are brought to you by your auditory sensory system, beginning with the ear and ending with the brain.

Begin your study of the auditory sensory system by reading about Hearing and Sound on pages 397 to 398 in your text. This is a general description of how sound waves are converted into mechanical energy and finally into nerve impulses. Then read pages 395 to 396 to gain an appreciation for the functional parts of the ear. Notice that most of the ear is actually inside your head.

After reading, answer the following questions.

1. For each of the following descriptions write the term that best matches the description.

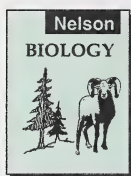
- _____ a. the external ear flap that collects the sound
- _____ b. funnels sound and produces ear wax
- _____ c. vibrates in response to sound entering middle ear



- _____ d. first of the ossicles to vibrate and transmit sound
- _____ e. last of the ossicles to vibrate and transmit sound
- _____ f. vibrates when struck by the stapes
- _____ g. air tube that allows equalization of pressure
- _____ h. chamber that detects static equilibrium
- _____ i. fluid-filled chambers that detect acceleration
- _____ j. contains the receptors that are sensitive to sound

2. Identify three sources of interference with the transmission of sound vibrations to the inner ear that might result in conduction deafness.

Check your answers by turning to the Appendix, Section 3: Activity 3.



In order to hear sounds, sound waves must be conducted to the inner ear. This form of energy must then be converted into nerve impulses. Using information from pages 397 to 399, answer the following questions.

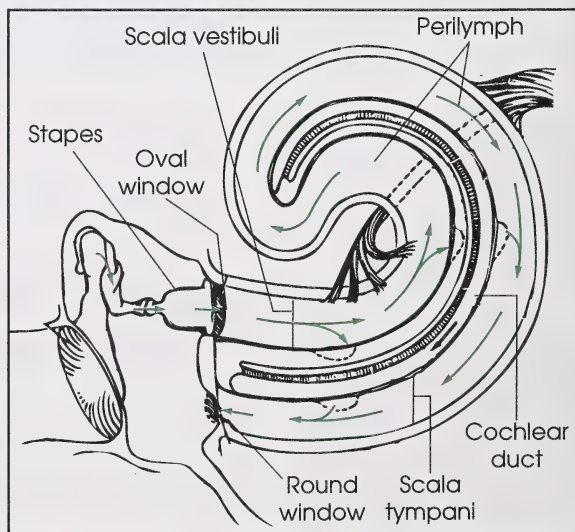
3. Complete Review questions 15, 16, 18, and 19 on page 399 in your text.
4. Trace the pathway travelled by an incoming sound from the pinna to the auditory nerve and brain.

Science Skills

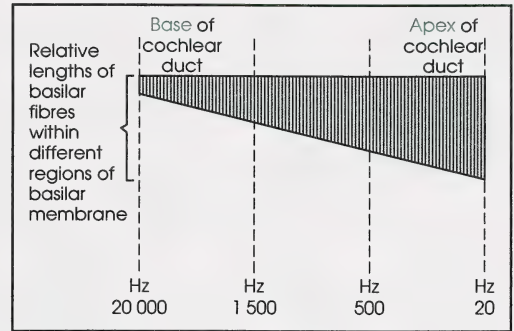
- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

Using the following diagrams and Figure 16.16 on page 398 in your text, answer the following questions.

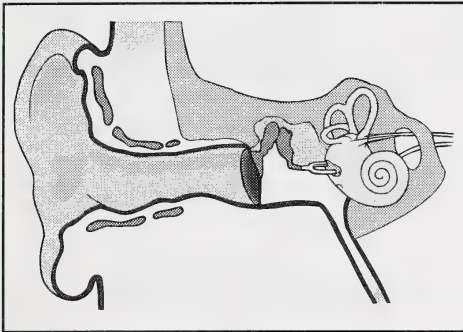
5. How do round window vibrations contribute to a "ringing" or reverberation in your ears?



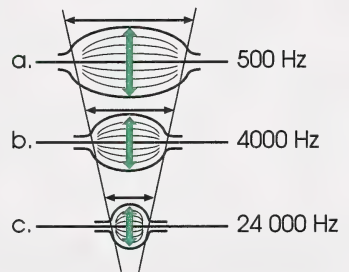
6. Relate the length of basilar fibres (hair cells of the organ of Corti) to the frequency or pitch of sounds discriminated.
7. Identify the pitch and loudness of the sounds that create the basilar membrane vibrations shown in the following graphic (a, b, and c).



amplitude – a measure in decibels of the loudness of a sound



Amplitude
of basilar
membrane
vibrations

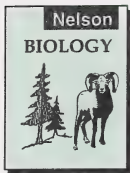


Check your answers by turning to the Appendix, Section 3: Activity 3.

As you probably learned in the first part of this activity, the ear functions as a balance organ as well as a hearing organ. Have you ever had an infection of your inner ear that made you so dizzy you couldn't stand up? Hopefully not, but you should know something about how your inner ear gives you a sense of balance and motion.



WESTFILE INC.



To learn about the relationship between the inner ear and balance, review pages 398 and 399 in your text. After reading, answer the following questions.

8. Complete Review questions 17, 21, and 22 on page 399 in your text.
9. The vestibular nerve carries impulses from the utricle, saccule, and semicircular canals to the cerebellum. Evaluate the effect of severing these nerves on your ability to discriminate equilibrium.

Check your answers by turning to the Appendix, Section 3: Activity 3.

To evaluate the impact of sound waves and the equilibrium of humans, perform the laboratory Hearing and Equilibrium as found on page 400 in your text.

Investigation: Hearing and Equilibrium

Objective

The objective of this investigation is to investigate environmental factors that affect both hearing and equilibrium.

Materials

- Refer to the list in your text. You may substitute a 30 cm ruler for the meter stick if necessary.

Procedure

- Factors That Affect Hearing: Complete steps 1 to 5.
- Equilibrium: Complete steps 6 to 8 if you have the materials.

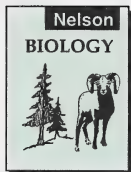
Observations

10. Complete the Procedure questions a to h from page 400.

Analysis and Interpretation

11. Complete Application questions 1 to 5 from page 400.

Check your answers by turning to the Appendix, Section 3: Activity 3.



Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

Your sense of hearing is well worth protecting. Have you ever seen hearing impaired persons communicating by sign? Much skill and concentration is required.



Follow-up Activities

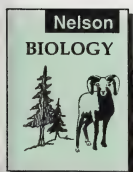
If you had difficulty understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

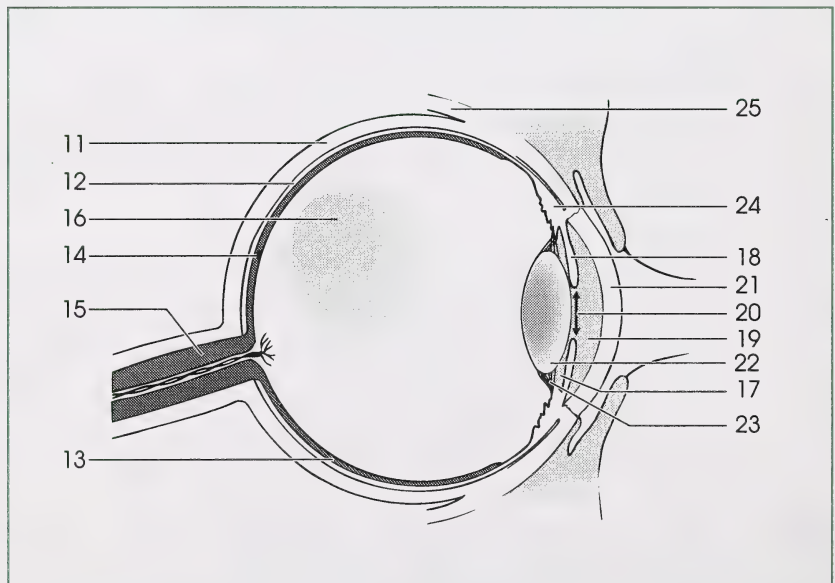
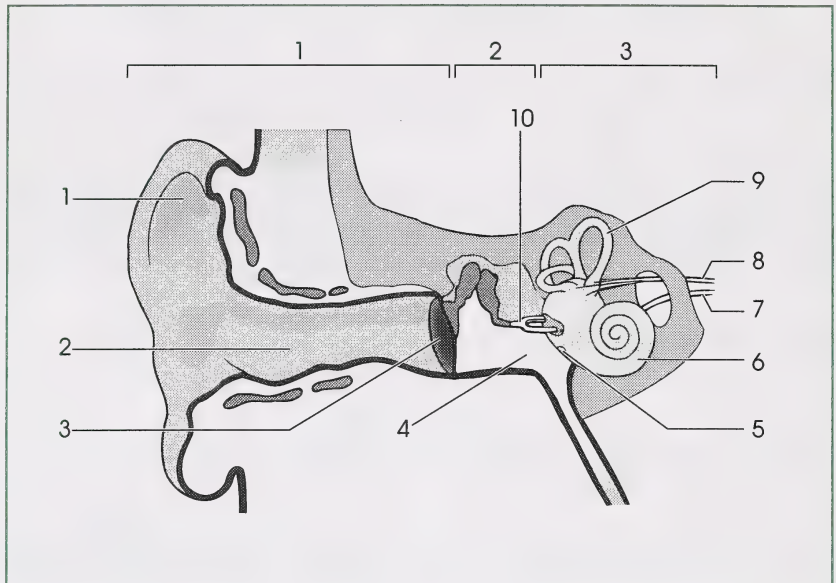
In this section you have learned about the somatic and special senses. You are an organism capable of detecting and responding to many different stimuli. Your brain creates reality from the sensory input. Basically, receptors such as the eye or ear receive information, light, or sound and change the information into a nerve impulse. The impulse travels to the appropriate area in the brain and you become aware of it. It works the same way for taste, smell, and all other senses.

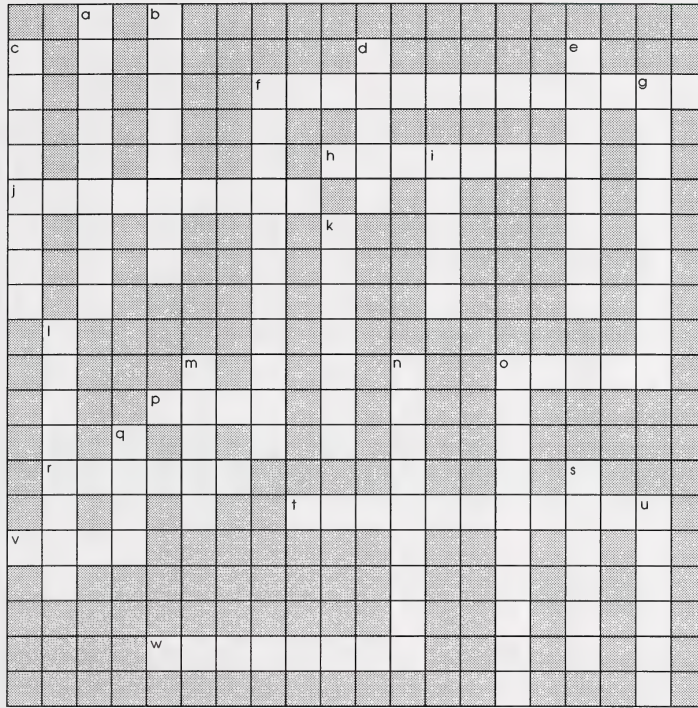
1. Using the data in Table 16.1 on page 381 in your text, categorize the receptors into two groups: somatic senses or special senses.
2. Defend the following statement.

Sensations occur in the brain and not in the receptor.



3. Using the diagrams and your knowledge of the special senses of hearing and vision, complete the following crossword puzzle.





Across

- f. focus reflex by the lens
- h. lobe that receives impulses from ear
- j. light-sensitive pigment
- o. ear diagram label #9
- p. sensitive to dim light
- r. eye diagram label #21
- t. static or dynamic
- v. eye diagram label #22
- w. Eustachian tubes equalize this

Down

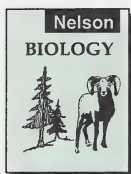
- a. farsightedness
- b. canal in ear diagram label #2
- c. clouding of the lens or cornea
- d. eye diagram label #14
- e. ear stones that help in balance
- f. irregular curvature of eye
- g. lobe that receives impulses from eye label #15
- i. ear diagram label #1
- k. ear diagram label #6
- l. hammer, anvil, stirrup
- m. provides for colour vision
- n. contains the utricle and saccule
- o. part of the brain which maintains balance
- q. eye diagram label #18
- s. oval and round
- u. nearsightedness

Check your answers by turning to the Appendix, Section 3: Extra Help.

Enrichment

Do one or more of the following.

1. Investigate a career that utilizes your knowledge and understanding of coordination and regulation in humans. Physiotherapy is a suggestion.
2. Losing one of your senses can help you develop the sensitivity of another sense. Contact the Canadian National Institute for the Blind to find out about the history and use of Braille. Ask for the Six Magic Dots of Braille pamphlet.
3. Research the impact of photoperiods and light wavelengths on the human organism.
4. Complete the Critical-Thinking questions 1 and 2 on page 403 in your text.



Check your answers by turning to the Appendix, Section 3: Enrichment.

Conclusion

In this section you have learned that your senses enable you to detect certain changes in your environment. The discrimination of stimuli by the brain creates your perception of the world. Your responses to those perceptions formulates your participation in life.

35

Section 3 Assignment: Sensing the Environment

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 1 Section 3 Assignment Page # Name and ID#

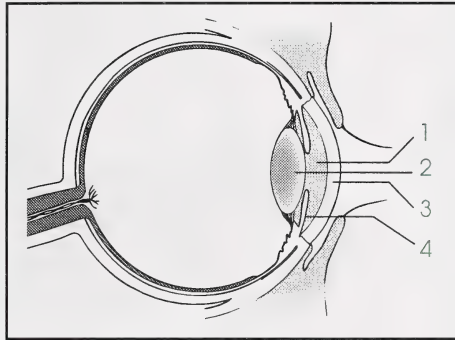
Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. Which of these stimuli would evoke a response in a Pacinian corpuscle?
 - A. gravity
 - B. heat or cold
 - C. sound
 - D. pressure

2. The blind spot of the eye is the area of the retina that contains
- neither rods nor cones
 - both rods and cones
 - cones but no rods
 - rods but no cones

Use the following diagram to answer question 3.

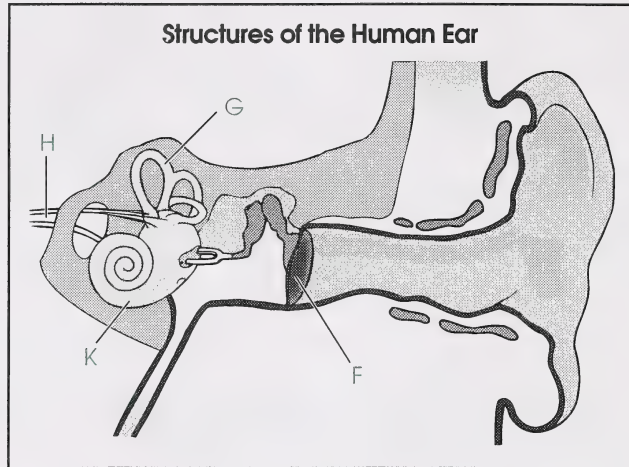


3. Focusing to adjust for changes in object distance is primarily accomplished by the structure in the diagram labelled
- 1
 - 2
 - 3
 - 4
4. The condition in which some portions of an image are in focus on the retina and other portions are blurred is called
- presbyopia
 - hyperopia
 - astigmatism
 - myopia
5. Glasses with concave lenses help correct
- presbyopia
 - myopia
 - hyperopia
 - astigmatism

6. Which of the following would cause a form of conductive deafness?

- A. tumour in the brain
- B. use of streptomycin
- C. torn tympanic membrane
- D. damage to the vestibular nerve

Use the following diagram to answer question 7.

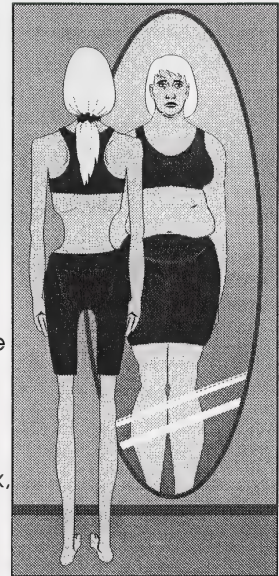


7. Some children like to twirl around in one place. After they stop twirling, they feel as though they are still moving. This feeling is caused by continued
- A. vibrations of F
 - B. movement of fluid in G
 - C. movement of fluid against K
 - D. transmission of nerve impulses from K to H
8. The ear structure that converts the mechanical energy of sound to nerve impulses is the
- A. organ of Corti
 - B. Eustachian tube
 - C. tympanic membrane
 - D. third ossicle (stirrup)
9. When the oval-window membrane is forced inward toward the fluid in the inner ear,
- A. the round-window membrane is also forced inward
 - B. fluid is forced toward the bones of the middle ear
 - C. the round-window membrane is forced outward
 - D. fluid is forced out of the cochlea

Use the following information to answer question 10.

Anorexia nervosa is a condition characterized by severe weight loss and great anxiety about becoming overweight. The condition has both physical and mental components. Cultural values placed on being thin may be a factor. Generally the victim refuses to eat and is obsessed with losing as much weight as possible. As an abnormal amount of weight is lost, a number of symptoms develop. These may include any of the following:

- chapped lips
- abdominal pain
- yellowish skin
- fainting spells
- constipation
- muscle wasting
- anemia
- insomnia
- swelling of the feet
- growth retardation
- low white cell count
- abnormal heart rhythm
- dry, cracking, flaking skin
- irregular menstrual periods
- decreased body temperature
- decreased immunity to infections
- organ shrinkage (heart and brain)
- hair growth on the face, back, and arms
- osteoporosis, fractures, and loss of ability to walk
- emaciated appearance



Permanent damage to body organs can occur and death is a possibility if no treatment occurs. Most individuals with anorexia nervosa fail to recognize how underweight and undernourished they are despite persistent comments from others. All suggestions of food become repulsive and weight loss continues.

10. Using specific examples, describe three sensory distortions that may occur as a result of anorexia nervosa. **(3 marks)**
11. Provide three examples of technology (procedures, equipment) and explain how each example could enhance or disrupt sensory perceptions. **(3 marks)**

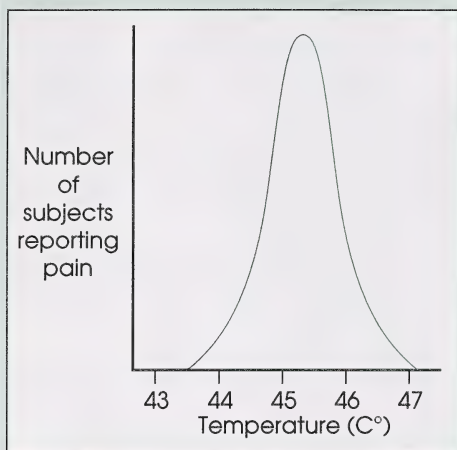
Communication (2 marks)

Use the following information to answer question 12.

Pain is a protective mechanism for the body. It occurs whenever tissues are being damaged and it causes you to react to remove the pain stimulus.

The pain receptors in the skin and other tissues are all free nerve endings. Most pain fibres are more responsive to extensive mechanical stretch, heat or cold, and specific chemicals in the tissues than any other stimuli.

The following graph presents data from experimentation with skin temperatures that cause pain.



A distribution curve was obtained from a large sample of subjects.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

12. a. Determine the relationship the experimenters were trying to test. **(1 mark)**
- b. Based on the data presented in the graph, identify a logical inference for this experiment. **(1 mark)**
- c. Using specific examples in the reception, transmission, and integration of the stimuli detected, explain the variation of the results. **(3 marks)**
- d. Evaluate the use of pain-killers by humans in terms of advantages and disadvantages. **(2 marks)**

Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self: A.	B.	C.	D.	E.	F.
Teacher: A.	B.	C.	D.	E.	F.

13. a. In relation to the diagram, state the direction from which light enters the retina. (1 mark)

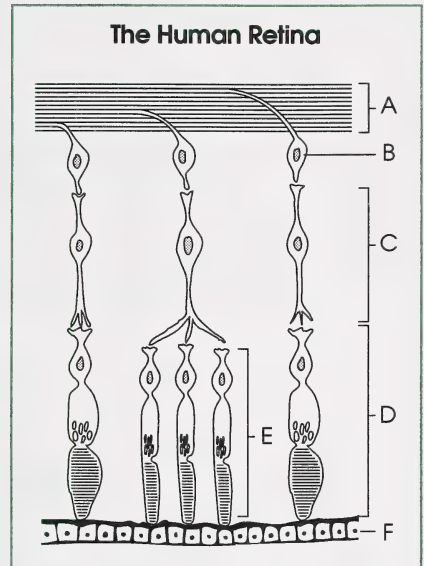
- b. Using the label letters in the diagram, match the structure with the correct description. (4 marks)

_____ contains photosensitive rhodopsin for dim light vision

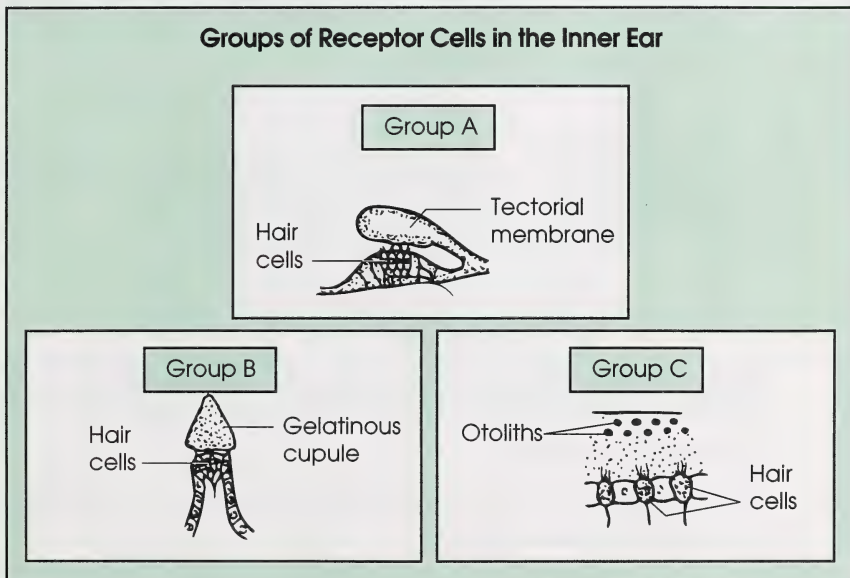
_____ axons form the optic nerve relaying impulse to the brain

_____ responsive to different wavelengths of bright light

_____ synapse directly with the photoreceptors



Use the following diagrams to answer question 14.

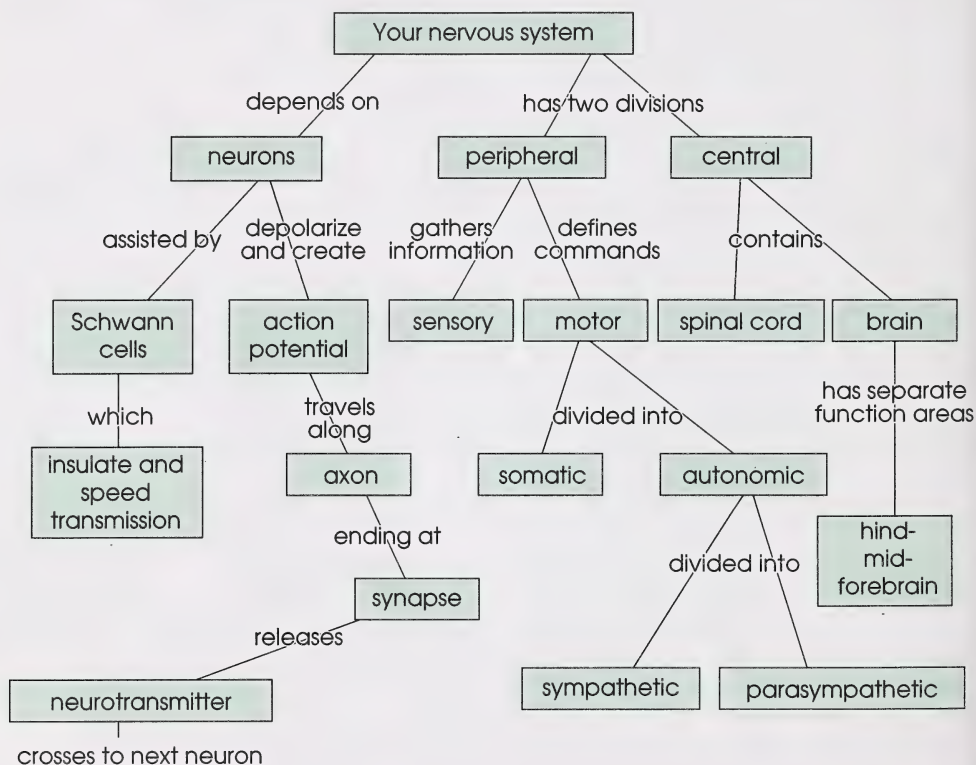


14. a. Identify the specific part of the inner ear that contains each group of cells. (3 marks)
- b. Describe the kind of stimulus detected by each group of cells, how the stimulus is transmitted to the brain, and the sensation it creates. (3 marks)

MODULE SUMMARY

In this module you learned that humans sense their internal and external environment with an electrochemical control system called the nervous system. On the basis of information from these two environments, conscious and unconscious decisions are made. The decisions are followed by responses that may alter physiological processes or provide responses to the environment.

You are a complex organism constantly acting to maintain that dynamic condition called life. The following concept map highlights the major factors in your nervous system.



To ensure that all of your work has been completed in a satisfactory manner, check off the items in the following list:

- ☐ Section 1 Assignment has been completed.
- ☐ Section 2 Assignment has been completed.
- ☐ Section 3 Assignment has been completed.
- ☐ Your responses are organized and neat, with room for teacher comments.
- ☐ All your response pages are numbered consecutively and identified with this heading.

Appendix

	Science Skills
	Glossary
	Suggested Answers
	Snellen Eye Chart

Science Skills

A Framework for Scientific Problem-Solving Skills

A. Initiating and Planning

- Identify and clearly state the problem or issue to be investigated.
- Differentiate between relevant and irrelevant data or information.
- Assemble and record background information.
- Identify all variables and controls.
- Identify materials and apparatus required.
- Formulate questions, hypotheses, and/or predictions to guide research.
- Design and/or describe a plan for research or to solve the problem.
- Prepare required observation charts or diagrams.

B. Collecting and Recording

- Carry out and modify the procedure if necessary.
- Organize and correctly use apparatus and materials to collect reliable experimental data.
- Accurately observe, gather, and record information or data according to safety regulations (e.g., WHMIS) and environmental considerations.

C. Organizing and Communicating

- Organize and present data in a concise and effective form (themes, groups, tables, graphs, flow charts, and Venn diagrams).
- Communicate data more effectively, using mathematical and statistical calculations where necessary.
- Express measured and calculated quantities to the appropriate number of significant digits and use appropriate SI units for all quantities.

D. Analysing

- Analyse data and information for trends, patterns, relationships, reliability, and accuracy.
- Identify and discuss sources of error and their effect on results.
- Identify assumptions, attributes, bias, claims, or reasons.
- Identify main ideas.

E. Connecting, Synthesizing, and Integrating

- Predict from data or information.
- Formulate further testable hypotheses supported by the knowledge and understanding generated.
- Identify alternatives for consideration.
- Propose and explain interpretations or conclusions.
- Develop theoretical explanations.
- Relate the data to laws, principles, models, or theories identified in background information.
- Answer the problem investigated.
- Summarize and communicate findings.
- Decide on a course of action.

F. Evaluating the Process or Outcomes

- Establish criteria to judge data or information.
- Consider consequences and perspectives.
- Identify limitation of the data, information, interpretations, or conclusions as a result of the experimental/research/project/design processes or methods used.
- Suggest alternatives and consider improvements to experimental technique and design.
- Evaluate and assess ideas, information, and alternatives.

Criteria for Assessing Scientific Problem-Solving Skills

A. INITIATING AND PLANNING

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Proposes a simple problem statement when initiated to do so	Proposes a simple problem statement	Proposes a problem to be investigated	Clearly states the purposes and problem to be investigated	Performs at a level beyond level 4
Background information must be supplied	Background information is supplied from teacher or student's own experience	Background supplied by teacher, reference material, or student's own experience	Prepares the necessary background information from references, research, discussion, and/or past experience	Characteristic of work done at college or university level
Identifies those things that change and those that stay the same	Identifies variables and controls	Identifies controls, manipulated variables, and responding variables	Identifies the controls and variables	
Guesses about the outcomes	Makes 'educated' guesses	Makes a prediction and/or suggests a simple hypothesis	- Forms an appropriate hypothesis and prediction - Designs an investigation	
Identifies simple materials and equipment to be used	- Identifies materials and equipment to be used - Is able to assemble simple apparatus	- Identifies the materials and equipment to be used - Assembles simple apparatus	- Identifies and names the materials and equipment to be used - Assembles and designs or modifies simple apparatus	
Follows directions as provided	- Follows directions as provided - Is able to write simple procedural statements	Develops and organizes a simple written procedure	Designs and writes descriptions of procedures that are clear and detailed	
	Prepares observation charts, tables, and diagrams as directed by teacher	- Prepares observation charts, tables, diagrams, graphs - Performs calculations as outlined by teacher	- Prepares observation charts, diagrams, and graphs - Performs necessary calculations	

B. COLLECTING AND RECORDING

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Follows a simple procedure	Follows a simple procedure	Follows a given procedure and is able to suggest modifications when asked to do so	Follows a given procedure and modifies the procedure when necessary	Performs at a level beyond level 4
Correctly uses apparatus and materials as directed by teacher	Correctly uses apparatus and materials with little teacher assistance	Correctly uses apparatus and materials with infrequent modification	Consistently uses standard apparatus and materials correctly	Characteristic of work done at college or university level
Collects data using concrete, tangible objects	- Collects tangible objects - Carries out simple measurements	Accurately collects data	Accurately collects relevant data	
Records data in sentence form or in simple charts that have been constructed	- Records data in numerical and non-numerical form - Is able to use and construct simple charts	Records relevant data including the correct units with respect to measured data	Records relevant data using the appropriate units	
- Is aware of safety and environmental concerns - Follows stated safety procedures	- Is aware of safety and environmental concerns - Follows stated safety procedures	Shows appropriate safety and environmental concerns in the use, care, and maintenance of materials and apparatus	Demonstrates appropriate standards of safety	
		- Is able to locate appropriate safety regulations - Actively participates in teacher-directed discussion of safety and environmental issues	Is able to suggest modifications to procedures to minimize environmental damage	

C. Organizing and Communicating

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Organizes data in sets of concrete objects	Organizes data in sets of objects	Organizes data in the form of sets, themes, and/or tables	Organizes data accurately	Performs at a level beyond level 4
	- Provides a basis for the organization of data sets - Constructs simple graphs to represent the data	- Provides a basis for and suggests alternatives for the organization of data - Is able to construct graphs and/or tables to represent the data	Is able to represent data using appropriate graphs and tables	Characteristic of work done at college or university level
	Performs basic mathematical calculations	Performs basic mathematical calculations	Performs relevant and required mathematical calculations	
	Identifies, with teacher assistance, errors and inaccuracies	- Identifies errors and discrepancies in data - Takes part in teacher-directed discussion of scientific inaccuracies	Expresses measured and calculated quantities to correct degree of precision	

D. Analysing

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Correctly identifies patterns within the data	Assesses patterns and trends that are conceptually presented by the data	Assesses patterns, trends, and simple relationships	Assesses patterns, trends, and relationships resulting from collected and manipulated data	Performs at a level beyond level 4
Identifies, with teacher assistance, relationships	Identifies simple cause and effect relationships	Identifies cause and effect relationships	Identifies the sources of error in data collection and manipulation	Characteristic of work done at college or university level
	Identifies, with teacher assistance, the sources of error in data collection and manipulation	Identifies the sources of error in data collection and manipulation	- Expresses accuracy qualitatively and/or quantitatively (percent difference), where applicable - Identifies the assumptions relating to measurement and/or analysis	
	Identifies, with teacher assistance, the effect of errors on results	Suggests amendments to procedures and/or data manipulation in order to rectify results	Determines the reliability of the data	

E. Connecting, Synthesizing, and Integrating

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Provides a simple but not necessarily appropriate answer to the problem investigated based on results obtained	Provides a simple answer that is appropriate for the problem investigated and results obtained	Provides an appropriate answer to the problem investigated based on results obtained	Provides a qualified answer to the problem investigated	Performs at a level beyond level 4
	Attempts to relate results to knowledge that is not specifically related to scientific theories or laws	Relates results, with teacher assistance, to applicable theories and/or laws	Relates the data to laws, principles, models, or theories identified in background information and/or in broader context	Characteristic of work done at college or university level
			- Proposes and explains interpretations or conclusions - Develops theoretical explanations	

F. Evaluating the Process or Outcomes

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Attempts to explain results to the problem investigated	Attempts to explain results to the problem investigated	Is able to explain the results obtained in light of the problem being investigated	Evaluates the prediction and concepts	Restricts, revises, or replaces an unacceptable scientific concept
	Attempts to draw conclusions where applicable and when prompted	Draws conclusions and attempts to explain them	Draws conclusions and attempts to explain them	Establishes criteria to judge the design, prediction, and concepts
		Discusses the limitations of the data collected, interpretations, and/or conclusions	Identifies limitations of the data and information, interpretations, or conclusions, as a result of the design of the experiment, research, or project	- Considers consequences and perspectives - Evaluates assumptions and effects of bias
		- Discusses, when prompted, the validity of results - Discusses, when prompted, alternatives and/or improvements to the experimental design	Suggests alternatives and considers improvements to experimental technique and design	Evaluates the total investigation in terms of reliability and validity

Glossary

amplitude: a measure in decibels of the loudness of a sound

anaesthetic: a substance that produces a loss of sensation

continuous conduction: the transmission of a nerve impulse from one set of gates to the next

electrochemical: describes the relationship between the movement of ions and creation of an electrical potential

encapsulate: to enclose or wrap as in a capsule of ions and the creation of an electrical potential

meningitis: a bacterial disease in which inflammation of the meninges occurs

myelination: having a myelin sheath around a neuron

neurilemma: the cell membrane surrounding a Schwann cell of a myelinated neuron

neuromuscular junction: the space between the axon terminal of a motor neuron and a muscle fibre

neurotransmitter: a chemical substance secreted by an axon terminal that stimulates another neuron or muscle

photomicrograph: a photograph of the magnified image of an object

physiology: the branch of science dealing with the study of body functions

polarity: the electrical charge on the surface of a membrane due to the unequal distribution of ions on either side of the membrane

receptive field: the area whose stimulation results in the generation of nerve impulses in a sensory neuron

saltatory conduction: the transmission of a nerve impulse by apparent jumping from one node of Ranvier to the next

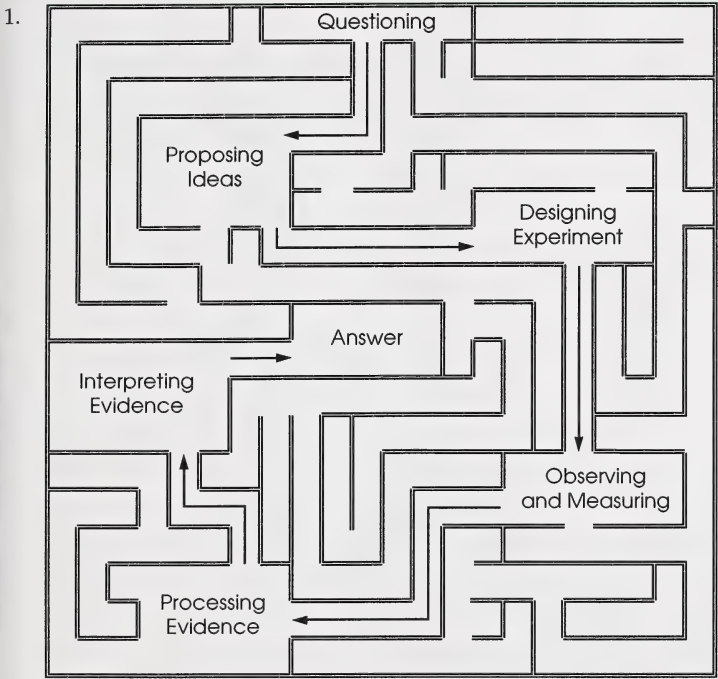
somatic senses: involving receptors associated with skin, muscles, joints, and internal organs

stereoscopic: two slightly opposed views that create a three-dimensional effect or a sense of depth

tactile: relating to the sense of touch

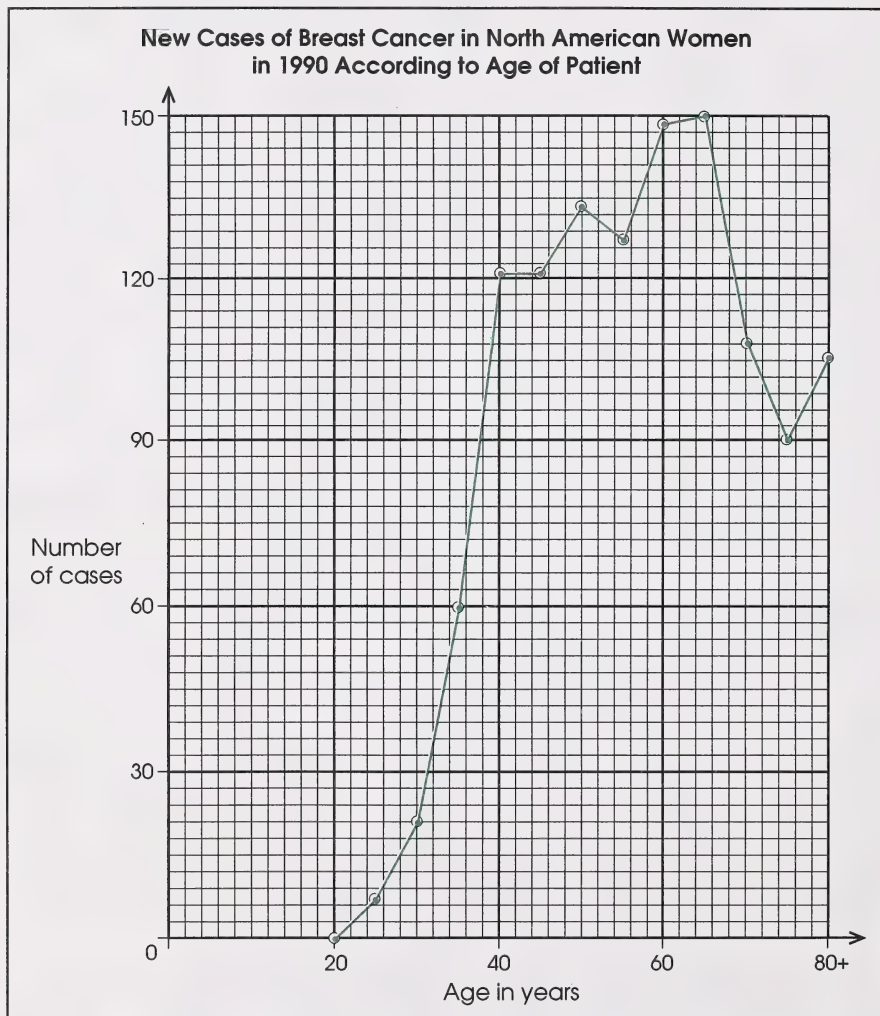
Suggested Answers

Section 1: Activity 1

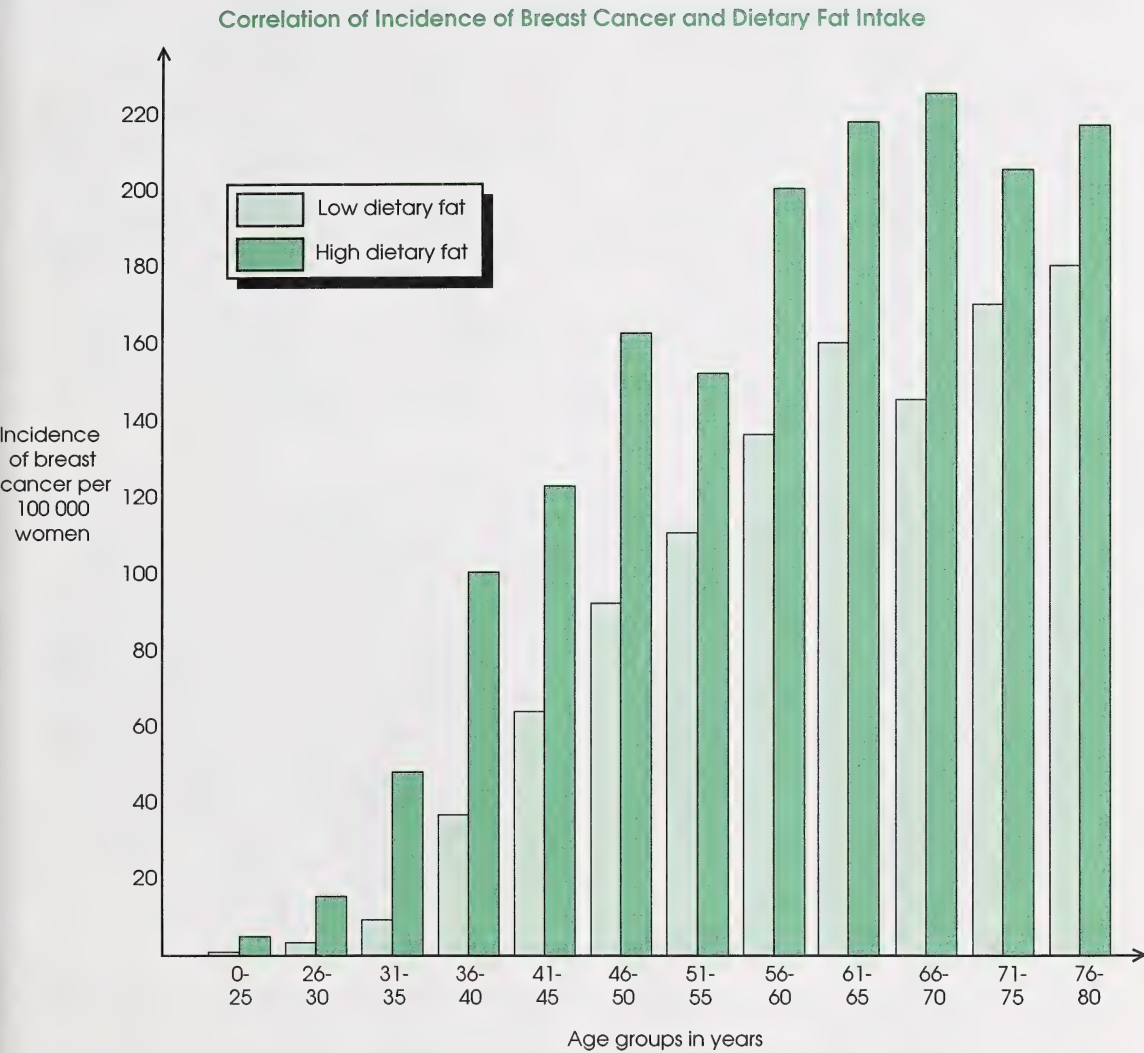


2. The sequence generally follows a pattern such as questioning, proposing ideas, designing the experiment, observing and measuring, processing evidence, and interpreting evidence.
3. The research team wants to find out if breast cancer can be reduced by decreasing dietary fat and increasing dietary carbohydrate intake.
4. Dietary fat intake and dietary carbohydrate intake will be the two manipulated variables in the investigation.
5. The responding variable will be the incidence of breast cancer.
6. The research team may identify a large number of controlled variables. Here are some possibilities:
- age of subjects
 - geographic location
 - other diseases in patients
 - genetics
 - sex
7. Evidence suggests breast cancer can be influenced by environmental factors. Incidence of breast cancer varies around the world and is five times greater in North America and western Europe than in Japan or most of Asia. Differences are not genetic but may be linked to dietary fat. Animal research supports this.
8. The incidence of breast cancer can be reduced by decreasing dietary fat and increasing dietary carbohydrate. Evidence suggests that breast cancer is influenced by environmental factors such as dietary fat. Nine thousand five hundred high-risk patients in Canada and the United States will be studied to determine if low-fat diets reduce the incidence of breast cancer.

9. The prediction is part of the hypothesis. It is that low-fat diets may reduce the incidence of breast cancer.
10. The team will follow 9500 high-risk patients in Canada and the United States for ten years.
11. The team will collect data on the patients' diet, general health, and any occurrences of breast cancer. There may be many other types of data collected.
12. Analysis of data is practically a field of its own. Have you ever heard of statistics? Some possible ways of analysing and displaying data include constructing tables, charts, and graphs; finding rates of change; calculating averages; and finding relationships between variables. There are many more kinds of tests.
13. Your graph should look like this. Pay attention to the ten rules of good graphing.



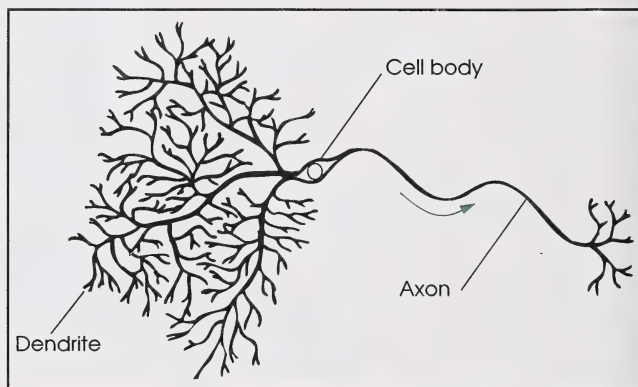
14. Bar graphs do not have to be drawn on graph paper, but clear horizontal reference is necessary. Your graph might look like this.



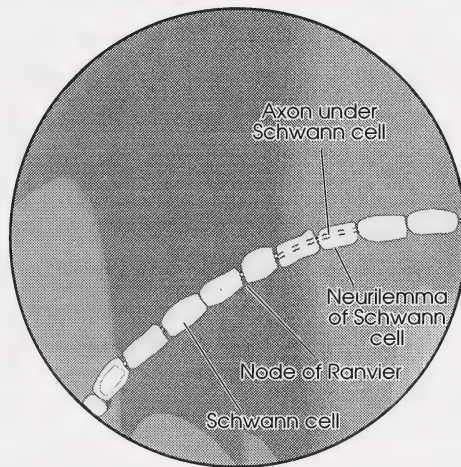
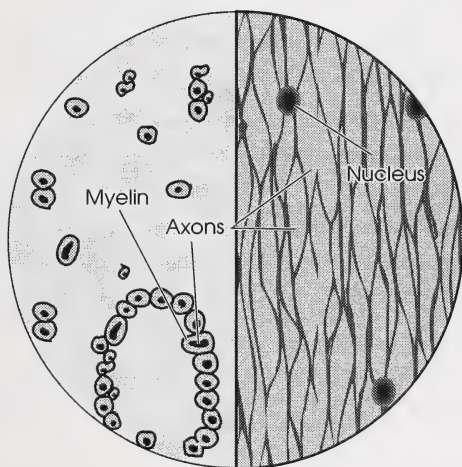
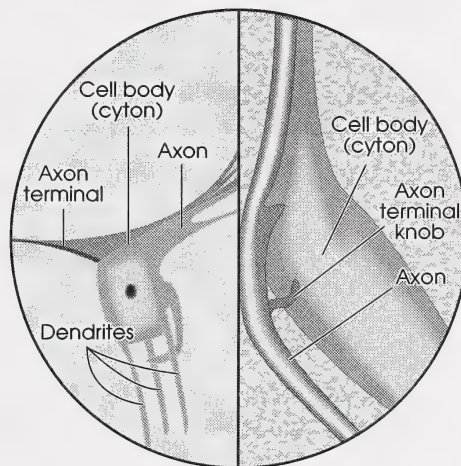
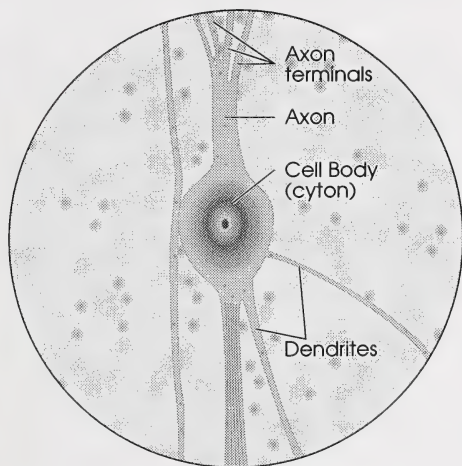
15. a. Graph A shows a positive relationship between the incidence of breast cancer and dietary fat. It supports the hypothesis and correctly illustrates the cause and effect relationship.
- b. Graph B shows a positive relationship between the incidence of breast cancer and dietary fat but is drawn incorrectly. It shows that as breast cancer increases, dietary fat increases. The relationship is reversed. Graph C compares the incidence of breast cancer to age, not dietary fat. Graph D is drawn correctly but proves that the hypothesis is false. It does not support the hypothesis.

Section 1: Activity 2

1. Memory, learning, and language are three components often used to separate humans from other animals when describing the complexities of the nervous system.
2. The central nervous system, or CNS, is composed of the brain and spinal cord. All sensory information (input) is integrated and all motor information (output) is coordinated. The peripheral nervous system, or PNS, is composed of all the nerves that relay sensory and motor information between the organs of the body and the CNS. The PNS has voluntary (somatic) and involuntary (autonomic) nerves.
3.
 - a. A sensory neuron transmits information from receptors to the CNS. A motor neuron transmits information from the CNS to muscles and glands to elicit responses. While the direction of transmission is different, the structure of the cells and the mechanism of transmission are similar.
 - b. A dendrite is the receiving end of the neuron. It possesses receptor sites for neurotransmitters. This could be a physical or chemical stimulus. An axon is the transmitting end from one neuron to the next. It releases neurotransmitters. Both parts of a single neuron will transmit nerve impulses along their membranes by the same mechanism. Notice Figure 15.3 on page 352 in your text.
 - c. Myelin sheaths are formed by Schwann cells and serve to insulate axons. The nodes of Ranvier expose the neural membrane so impulses can be transmitted. The neurilemma is a protective covering around the axon of neurons. It promotes regeneration in damaged neurons. Both layers provide protection to the delicate neuron and are formed by Schwann cells. **Note:** Your answer must bring out points of similarity and points of difference when you compare these terms.
4. The drawing on the right is a sample illustration. Note the absence of a neurilemma because the neuron is found inside the CNS. This cell would be found in the grey matter of the spinal cord, because it does not possess a myelin sheath. If a sheath was present, the myelinated neuron would be found in the white matter. Find the interneuron on Figure 15.5 on page 354 in your text.
5. Since nerve impulses appear to jump from one node of Ranvier to another, the speed of transmission will be faster in a myelinated neuron. It should be noted that the smaller the diameter of the neuron, the faster the speed of transmission as well.
6. Neurons are the cells or functional units of the nervous system and transmit nerve impulses along their membranes. Nerves are composed of the axons and dendrites of many neurons. Figure 15.4 on page 352 of your text shows the nerve as a bundle of axons.



7. Your labelled diagrams should be similar to the ones shown here.



8. From the microslide descriptions, you have learned that the synapse is the place where adjacent neurons are close enough together for communication. The synapse provides an "ON-OFF switch" in the pathway of communication from neuron to neuron. Where a neuron communicates with a muscle cell or fibre, the site is called a neuromuscular junction. Note that these closely aligned cells do not actually touch one another. The gaps are like switches.
9. The sensory neurons have longer dendrites and shorter axons than the motor neurons. In sensory neurons, both dendrites and axons are myelinated to speed transmission. Sensory neurons carry nerve impulses from receptors toward the CNS, while motor neurons carry the impulses away from the CNS toward the effectors.
10. The stimulus is detected by a sensory receptor. The receptor stimulates a sensory neuron. The sensory neuron transmits to the interneuron in the spinal cord. The interneuron stimulates a motor neuron. The motor neuron communicates to the muscle. The muscle (effector) produces the response.

11. The reflex arc takes the most direct route from stimulus to response and does not require the brain's integration. As a result, the responses often occur before the sensation has been relayed to the brain. This is necessary to quickly protect the body from danger.
12. The only way to speed up transmission would be to myelinate the neurons. If this is already the case, the response could occur faster if there is no interneuron and the sensory neuron synapses directly to the motor neuron. This condition actually occurs and is known as a monosynaptic reflex arc like the knee-jerk.
13.
 - **Procedure question a:** The leg will move upward uncontrollably.
 - **Procedure question b:** The leg movement increases when the subject clenches the book.
 - **Procedure question e:** The eye that was closed has the larger pupil.
 - **Procedure question f:** The pupil that receives the light closes more quickly.
 - **Procedure question g:** The data you collect will vary depending on the individual tested. Usually the distance for the right hand is shorter than the distance for the left hand because of the conditioned use of the right hand. Southpaws will probably have reversed results. The distances will probably be between 4 cm and 30 cm. Generally the distance will shorten with increased concentration and practice.
14.
 - **Application question 1:** The yelling is not part of the reflex. The sensory information must be processed through many neurons in the brain before yelling occurs. The hand is withdrawn even before the student senses pain because the withdrawal is a reflex action.
 - **Application question 2:** The heat is detected, but the hand does not pull away from the heat source as part of the reflex. The person may still be able to consciously move the hand, but only after noticing that it is burned. The information would have to be processed by the CNS prior to any reaction.
 - **Application question 4:** The physician is checking for nerve damage. By moving progressively closer to the upper leg, the physician is attempting to locate the position of nerve damage. Nerves enter the spinal cord at various intervals. Those nerves that are found closer to the head are found in the upper areas of the spinal cord. Those found nearer the foot enter the lower areas of the spinal cord.

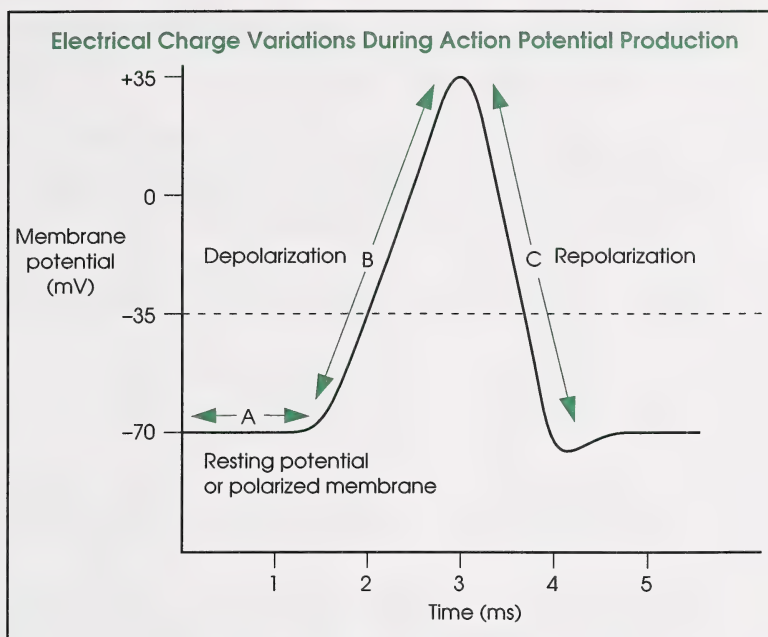
Section 1: Activity 3

1.
 - **Review question 7:** Nerves have a high resistance to electrical current, which would reduce a current as it travelled along the nerve. Nerve impulses, however, remain constant along the length of the nerve and also travel more slowly than electrical impulses. Electrodes placed inside nerves have detected electrochemical changes during the transmission of an impulse, confirming that nerve transmissions are electrochemical and not electrical.
 - **Review question 8:** The giant axon of a squid is useful for nerve research because of its large size. Electrodes can be inserted inside the axon. This allows scientists to monitor changes in electrical charge across the nerve cell membrane.
2. Sodium pumps actively transport Na^+ out of the neuron creating a high concentration in the extracellular fluid. Potassium pumps actively transport K^+ into the neuron creating a high concentration in the cytoplasm. This process requires the energy of ATP and creates concentration and voltage gradients (differences) which establish the resting potential or charge.

- The graph should be labelled as follows.

Section A – The membrane resting potential is a condition where Na^+ are diffusing into the neuron and K^+ are diffusing out of the neuron. Since more K^+ is leaving than Na^+ entering, the net accumulation of positive ions on the outside creates an electrical potential where the inside is negative.

Section B – A state of depolarization occurs when there is a change in the permeability of the membrane to Na^+ allowing a sudden influx of Na^+ . The electrical potential is altered and the charge on the inside of the membrane is reversed.



Section C – When the sodium gates close, the potassium gates open allowing a rapid outflux. This state of repolarization reverses the charge again and the membrane returns to its original electrical potential.

- Sodium ions move into the neuron because of the concentration gradient (high $\rightarrow$ low) and the voltage gradient (positive $\rightarrow$ negative).
- Since the refractory period is the time during which no new nerve impulse can be generated, the longer the refractory period, the lower the nerve impulse frequency (fewer per second).
- The action potential produces a region of depolarization which repolarizes very quickly. The charge across the membrane reverses during the nerve impulse generation and then returns to its resting state. Look again at Figure 15.10 on page 360 in your text.
- As the positive sodium ions rush into the cytoplasm at the depolarizing region, they will be attracted to the nearby negative regions of the resting membranes. This will begin to depolarize the next portion and when the threshold is reached, the next region will generate a new action potential before the refractory area has returned to its original resting state.
- Since the wave of depolarization moves from one region to the next faster than the depolarizing area can complete its refractory period, one-way transmission occurs. Impulses can only move away from the original point of stimulation.
- When a neuron is stimulated below its minimum responsive level, nothing happens, as a 1 mV stimulus in Figure 15.12 on page 361 in your text. The motor neuron will not cause the muscle fibre to contract. Any stimulation at or above the minimum threshold potential will result in the generation of an action potential, as 2, 3 or 10 mV stimuli in Figure 15.12 and the muscle will contract.

10. Stimuli below the threshold will not depolarize the resting membrane enough to produce a nerve impulse. Of course, stimuli above the threshold will open the Na^+ gates and depolarize the membrane. Subthreshold (below) stimuli elicit the “none” response, while suprathreshold (above) stimuli, elicit the “all” response.
11. Since the intensity and speed of transmission of the “all” response is constant for the varying suprathreshold (above) stimuli, there must be other methods for determining the intensity of the stimulus. Strong stimuli will increase the frequency of nerve impulses. They will also stimulate neurons with higher thresholds. By sending **more impulses** along **more neurons**, the brain will sense that the stimulus is more intense.
12. Each node of Ranvier exposes a small section of the membrane to the ECF. Since the myelin sheath insulates the membrane from the ECF, the only site for a movement of Na^+ and K^+ is the node. Therefore, a node of Ranvier allows action potentials to occur.
13. As nerve impulses jump from node to node, they effectively use less of the membrane to get from one end of the neuron to the other. Therefore, the speed of transmission increases when only a few Na^+/K^+ gates must open and close instead of all the gates along the membrane.
14.
 - **Review question 15:** Acetylcholine is released at the end plate of Neuron A. This causes depolarization of the dendrites of Neuron B. If the nerve impulse moved from the axon of Neuron B toward the dendrites it would not travel further. There is no transmitter chemical released from the dendrites of Neuron B.
 - **Review question 16:** Acetylcholine is a neural transmitter found in the end plates of many nerve cells. When acetylcholine is released, it causes the postsynaptic membranes (the membrane of the dendrite of the next neuron) to become more permeable to sodium ions. The influx of sodium ions causes an action potential. Cholinesterase is released after the acetylcholine. It destroys the acetylcholine, which causes the sodium channels to close, and it allows the nerve to begin its recovery phase.
 - **Review question 17:** Many neurons can meet at a synapse. In some cases, a single neuron is incapable of sufficiently depolarizing another neuron to cause an action potential. In cases such as this, chemicals released from two or more neurons may be required to initiate an action potential. This phenomenon is known as summation. A simple model is a truck stuck in the ditch. One person may not be able to push the truck out, but three or four people may be successful. Their summative effort will move the truck.

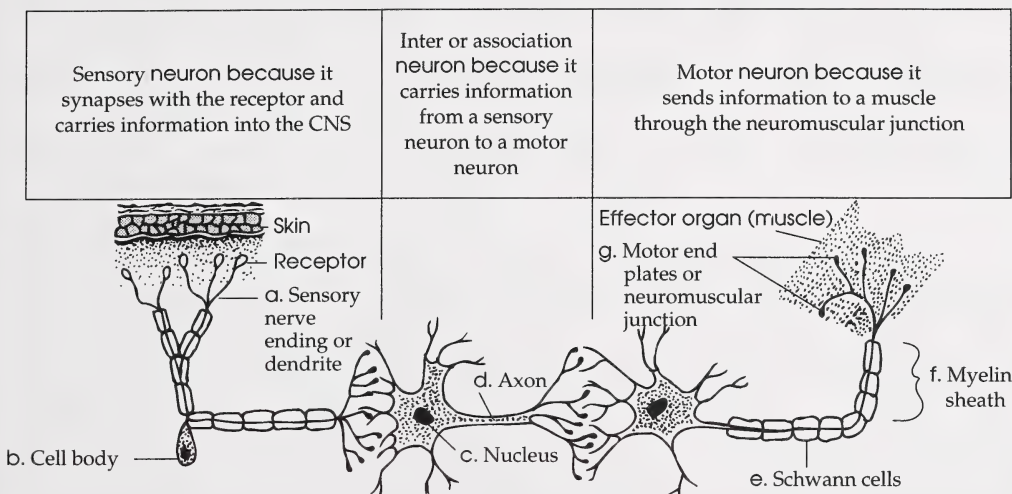
Section 1: Follow-up Activities

Extra Help

1. Each of the descriptions is found in order on pages 352 to 363 in your text.
 - b an extension of cytoplasm that carries nerve impulses away from dendrites
 - f the fatty covering over the axon of a nerve cell
 - k a condition of steady charge difference across the membrane
 - a a reversal of charge across the membrane and a return to rest
 - d a change in charge as a result of the influx of Na^+ in a neuron
 - j the recovery time before a neuron can produce a second impulse

- n minimum stimulation to create an action potential
- i neurons that carry impulses away from the synapse
- e the condition inside a neuron when more K^+ than usual leaves
- m the effect produced by an accumulation of chemical transmitters in the synapse

2.



3.

When the pin pricks the skin, it stimulates the receptor which generates nerve impulses in the sensory neuron. Transmission from dendrite to cell body and cell body to axon occurs. The association neuron is then stimulated and in turn sends impulses to the motor neuron. The result is a muscle contraction that moves the hand (skin) away from the stimulus (pin prick).

4.

- **Textbook question 9:** A polarized membrane has a net negative inside charge that is caused by the unequal distribution of positively charged ions. There are many more $\oplus$ ions outside the membrane than inside.
- **Textbook question 11:** The action potential causes ion gates in the cell membrane to open, allowing ions to flow across the membrane, effectively reversing the polarity of the membrane.
- **Textbook question 12:** The resting cell membrane is more permeable to potassium moving out than to sodium moving in. Thus, the outside of the nerve is positive relative to the inside. An impulse causes sodium gates to open, allowing sodium ions to diffuse into the nerve, depolarizing the membrane. This depolarization causes the sodium gates to shut and opens the potassium gates. Potassium diffuses out of the nerve. Sodium gates in adjacent areas open, and the action potential moves along the membrane. Sodium and potassium pumps then restore the polarization of the membrane.
- **Textbook question 14:** A certain threshold stimulus is required to trigger an action potential along a nerve. However, once this threshold level is reached, a further increase in the stimulus will not increase the response of the nerve; it is an all-or-none response. Basically a nerve either fires or it doesn't.

5. Matching the events correctly will make the diagram an excellent summary of synaptic transmission.

- b Acetylcholine is released from vesicles.
- f Acetylcholine is resynthesized.
- d The postsynaptic action potential is reached.
- a Presynaptic action potential arrives at synapse.
- e Acetylcholine is inactivated by acetylcholinesterase.
- c Acetylcholine binds to receptor, causing postsynaptic membrane excitation.

Enrichment

The answers to these questions should open the door to further research. You will find many other applications of the concepts presented in this section in your everyday experiences.

- **Textbook question 2:** If a leg had been severed, but the cell body of the sensory neuron remained intact, the neuron could continue to send information to the CNS.
- **Textbook question 3:** Multiple sclerosis is caused by the destruction of the myelin sheath that surrounds the nerve axons. The myelinated nerves in the brain and spinal cord are gradually destroyed as the myelin sheath hardens and forms scars or plaques. The destruction of the sheath results in short-circuits. Referred to as MS, multiple sclerosis often produces symptoms of double vision, speech difficulty, jerky limb movements, and partial paralysis of the voluntary muscles. Symptoms are progressive.
- **Textbook question 6:** Neuron X is an excitatory neuron. Its neuron transmitter causes the depolarization of neuron Y, making it easier to reach threshold level. Neuron W is an inhibitory neuron. Its neuron transmitter causes the hyperpolarization of the resting membrane Y, making it more difficult to achieve threshold level. When X and Y are stimulated together, their effects on neuron Y cancel each other.
- **Textbook question 7:** Without acetylcholine being produced, postsynaptic membranes would not depolarize. Nerve transmission would be severely inhibited, because although sensory nerves would respond to stimuli, motor neurons could not be excited. Walking, sitting, and other movements that require motor nerves could not occur. Even breathing movements would stop.
- **Textbook question 8:** The postsynaptic membrane would not undergo a recovery period. Without a refractory period, the neuron would not be able to receive another impulse. As well, constant firing would occur in the absence of cholinesterase.

Section 2: Activity 1

1. The major divisions are the central nervous system (CNS) and peripheral nervous system (PNS)
2. The CNS is made up of the brain and spinal cord.
3. The PNS contains sensory and motor somatic nerves and autonomic motor nerves.

4. Involuntary functions like digestion are controlled by the autonomic nerves in the peripheral nervous system.
5. Pain from a sliver would be conducted as an impulse along a sensory nerve.
6.
 - a. The **autonomic** nerves provide involuntary control of internal organs.
 - b. The CNS is composed of the **brain** and **spinal cord**. It functions to **coordinate all sensory and motor information**.
 - c. The **somatic** nerves provide sensory information about changes in the environment and control **skeletal muscles, bones, and skin**.
 - d. The **PNS** comprises all the cranial and spinal nerves which serve to **relay information between the body and the CNS**.
7. There are thirty-one pairs of spinal nerves. Refer to Figure 15.17 on page 367 of your text.
8.
 - **Review question 18:** Autonomic nerves are nerves that regulate the organs of the body without conscious control. Somatic nerves lead to muscles and are regulated by conscious control.
 - **Review question 19:** The two divisions of the autonomic nervous system are the sympathetic and parasympathetic systems. The sympathetic system prepares the body for stress, while the parasympathetic system restores normal body conditions. Sympathetic nerves have short preganglionic and long postganglionic nerves; parasympathetic nerves have long preganglionic and short postganglionic nerves. Both release acetylcholine from the preganglionic nerve, but the postganglionic nerves of the sympathetic system release norepinephrine, while the postganglionic nerves of the parasympathetic system release acetylcholine.
 - **Review question 20:** The vagus nerve is a major cranial nerve and is a part of the parasympathetic nervous system. Branches of the vagus nerve regulate the heart, bronchi, liver, pancreas, and digestive tract.
9.
 - a. Damage to the vagus would result in an inability to return most of the internal organs to their normal state of activity. As a result, high heart rate, no peristalsis in the digestive tract, no storage of glucose in the liver, a dilation of the pupils, and a relaxation of the bladder sphincter causing urination would occur. The net result is problems.
 - b. The second sympathetic nerve leads to the heart, larynx, bronchi, and lungs. Any damage to this nerve would prevent these organs from changing their activity to deal with stress. Heart rate would remain low and the respiratory organs would stay constricted.
 - c. Damage to the fifteenth sympathetic nerve would prevent the lower colon, rectum, bladder, uterus in females, and genitals in males from functioning in response to stress.
10.
 - a. Since the preganglionic sympathetic neurons release acetylcholine into the synapses of the sympathetic ganglia, there will be increased nerve impulses in the postganglionic sympathetic neurons. This will stimulate the internal organs in response to "stress." See the sympathetic responses in Table 15.1 on page 366 in your text.
 - b. Norepinephrine is not the correct neurotransmitter for these neurons, so there will be no effect.

- c. Increased acetylcholine will stimulate the postganglionic parasympathetic neurons causing a greater return to normal activity response. See Table 15.1 on page 366 for the parasympathetic responses.
- d. Once again, norepinephrine will not stimulate the postganglionic neurons to transmit nerve impulses. This neurotransmitter is released by the postganglionic sympathetic neurons and stimulates internal organs to respond to stress in a fight/flight pattern. You will learn more about this General Adaptation Syndrome in the next module.

Section 2: Activity 2

1. The cerebrum increases in size very noticeably from fish to amphibians, reptiles, birds, mammals, and finally humans. All primates (apes, monkeys, humans) have large cerebrums. Interestingly the cerebrum of whales and dolphins is quite large and highly folded too.
2. The cerebrum controls and stores sensory information and initiates motor activities. Speech, reasoning, memory, and personality are controlled from the cerebrum.
3. The cerebral cortex forms the outer region or surface of the cerebrum.
4. By having many folds or convolutions, the surface area of the cerebral cortex and the number of its cells can be increased without changing brain volume.
5.
 - Frontal lobe – voluntary movement, intelligence
 - Temporal lobe – vision, hearing, memory
 - Parietal lobe – touch, temperature, emotions
 - Occipital lobe – vision

The location of these functions is very important in diagnosing brain injuries.

6.
 - a. The frontal lobe controls speech.
 - b. Vision is controlled by the occipital lobe.
 - c. Finger snapping requires an understanding of meaning from the parietal lobe, a decision from the frontal lobe, a nerve impulse from the motor cortex, and sensory discrimination from the auditory and sensory cortex.
7.
 - **Review question 21:** The meninges of the brain are three protective membranes that surround the brain and spinal cord. Cerebrospinal fluid is a fluid that circulates between the innermost and middle meninges and through the central canal of the spinal cord. It acts as a shock absorber and as a nutrient and waste-transport system.
 - **Review question 22:** The brain is divided into many regions. The cerebrum is the largest and most highly developed area, and it is responsible for storing sensory information and for initiating voluntary motor activities. The olfactory lobes receive and interpret information about smell. The corpus callosum allows communication between the two hemispheres of the brain. The cerebellum coordinates muscle movements. The thalamus coordinates and interprets sensory information. The pons relays information between the cerebellum and the medulla. The medulla oblongata acts as the connection between the peripheral and central nervous systems.

- **Review question 23:** The four regions of the cerebral cortex are the frontal lobe, the temporal lobe, the parietal lobe, and the occipital lobe. The motor areas of the frontal lobe control movement of voluntary muscles. Association areas are linked to intellectual activities and personality. The sensory areas of the temporal lobe are associated with vision and hearing. Association areas are linked to memory and interpretation of sensory information. The sensory areas of the parietal lobe are associated with touch and temperature awareness. Association areas are linked to emotions and interpreting speech. Sensory areas of the occipital lobe are associated with vision. Association areas interpret visual information.
8. If the ventral root of the spinal nerves controlling the muscles of the legs is severed, then motor information cannot pass. Sensory information is relayed through the dorsal root, so it will enter normally. Damage to the spinal nerve or severing the spinal cord would result in paralysis and loss of sensation.
 9. With inflammation of the meninges comes an increased cerebrospinal fluid pressure. The resulting headache is one of the most severe humans can experience. Also, the pressure may affect neural transmission as grey (outer) matter is compressed in the brain.
 10. The grey matter of the cerebral cortex that is damaged would probably result in a loss of speech, motor control of swallowing, mastication (chewing), salivation, and vocalization, as well as some form of hearing loss from the auditory cortex. In short, you would lose your ability to communicate.
 11.
 - a. The medulla oblongata connects the peripheral and central nervous systems. It regulates involuntary muscles, breathing, heart rate, and other functions of the autonomic nervous system.
 - b. The pons is an enlarged area at the top of the spinal cord. It relays information between the areas of the cerebellum and the medulla.
 - c. The cerebellum controls balance and coordination.
 12. Your chart may be completed like this one.

Label	Structure	Function
Lobe A	frontal cerebral cortex	intellectual activity, personality, voluntary muscle control
Lobe B	parietal cerebral cortex	interpretation of speech, sensory awareness
C	corpus callosum	communication between right and left hemispheres
Lobe D	occipital cerebral cortex	interpretation of visual information
E	thalamus	coordination and interpretation of sensory data
F	hypothalamus	emotions, communication with endocrine system
G	pituitary	connection to hypothalamus and master endocrine gland
H	spinal cord	sensory and motor information, reflex arcs relay
I	cerebellum	coordination of limb movements, balance, muscle tone
J	medulla oblongata	connection of PNS and CNS, breathing, blood pressure, heart rate
K	pons	motor relay station between cerebellum and medulla

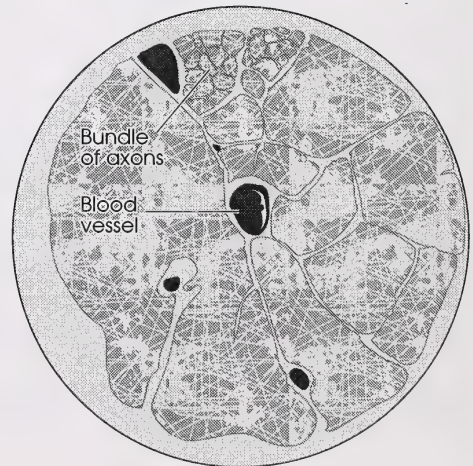
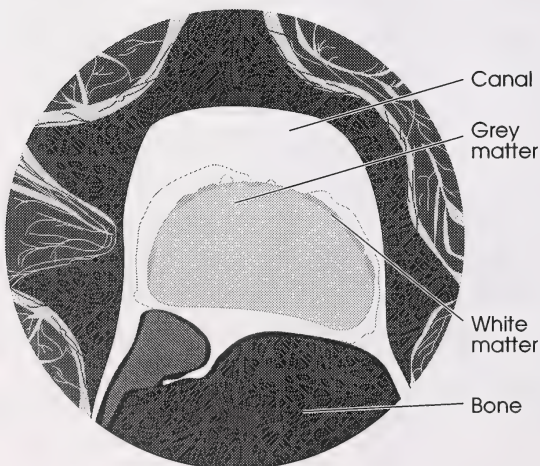
Because of the view, the **temporal lobe** is not visible. It integrates olfactory sensations, auditory sensations, and sensory memory.

Section 2: Activity 3

1. The nervous system takes in sensory information, integrates it into memory, and determines the appropriate responses. It allows you to participate in the world around you.
2. There are two basic divisions: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is composed of the brain and spinal cord and it is housed in protective bone. The PNS is composed of all the nerves, twelve pairs of cranial and thirty-one pairs of spinal nerves. It also includes the autonomic nervous system (ANS) which regulates the activity of the internal organs.
3. Sharon's brain uses visual data from her eyes, tactile information from her skin, and olfactory scents to trigger her memory so she can identify the objects. Finally, her taste buds give her chemical information which confirms the object is a peach.

Sensory Receptor	Cerebral Cortex Lobe
olfactory cells	parietal
rods and cones	occipital
hair cells in ear	temporal
higher intellectual activities	frontal

5. Jim's brain is better than a computer because it not only integrates sensory information and stores it, but it allows Jim to formulate and create ideas.
6. The ANS maintains homeostatic control of the circulatory, respiratory, and digestive systems. The cerebellum integrates proprioceptive (pressure, position) information from the muscular and skeletal systems to achieve involuntary coordination.
7. This thin layer on the inside of the retina is probably made of nerve cells.
8. Letter F on Slide 2 identifies the neurons that carry impulses to the optic nerve.
9. Your labelled diagrams should be similar to the ones shown.



10. The CNS is composed of the brain and spinal cord. It functions to interpret stimuli, integrate them with memory, and determine appropriate responses. The PNS is composed of all the nerves and the receptors. It relays information to the CNS and from the CNS to muscles and glands.
11. Using the information in the descriptions of slide set 69, your completed chart should look like this.

Structure	Function
cerebrum	control centre for voluntary actions and higher level mental activities
cerebellum	centre for muscle coordination and for balance
medulla	the link between brain and spinal cord that controls vital involuntary activities
grey matter	the irregular-shaped cell bodies in an area where many synapses occur
nerve	a main transmission line for sensory and motor data

Section 2: Activity 4

1. Neurotransmitters are stored and secreted from synaptic vesicles that are found in the axon terminals. The transmission of nerve impulses along the cell membrane initiates the release of the chemical into the synapse or neuromuscular junction.
2. Most transmitters stimulate the dendrite of the next neuron or the muscle cell by causing a depolarization of the membrane. This is done by increasing the permeability of the membrane to **sodium** ions. Some transmitters will have an opposing effect because they cause hyperpolarization of membranes. That is to say that these transmitters increase the membrane permeability to **potassium** ions. This will serve to inhibit the neuron and make it harder for nerve impulses or muscle contractions to occur.
3. The postsynaptic membrane of the dendrite releases an enzyme (cholinesterase) that destroys the transmitter. This returns the membrane to its original resting potential. It is then ready to receive another impulse.
4. Since acetylcholine stimulates skeletal muscle fibres, its release into the neuromuscular junction will cause the fibre membrane to depolarize and the fibre will contract. The subsequent release of cholinesterase will return the fibre membrane to its original resting potential as the transmitter is destroyed. The fibre will then relax.
5. Endorphins are natural painkillers produced by the brain. They work by occupying sites in the substantia gelatinosa (SG) of the brain, which are normally used by pain-signalling chemicals. The endorphins block the sites, reducing the intensity of the pain.
6. Since the opiates have a similar chemical structure to the endorphins, they can "fit" the endorphin receptor sites on the SG neurons. By so doing, they act in a similar way to your body's natural painkillers and inhibit the production of pain transmitters.
7. Artificial painkiller use will inhibit the body's production of natural painkillers. As a person stops making natural endorphins, the body becomes more sensitive to pain and dependent on the artificial substance. This leads to complete dependency or addiction.

8. An increased threshold level resulting from the action of alcohol will make an individual less sensitive to stimuli. Therefore, alcohol is a depressant similar in effect to the opiates. When the individual's tolerance to alcohol increases, it requires more alcohol to produce the depressing effect. Eventually the person cannot function without alcohol and is addicted.
9. Anaesthetics serve to inhibit nerve impulses by increasing membrane resting potentials just like alcohol. Modern products are more effective and they can be used to block specific neural pathways for specific periods of time.
10. By removing the inhibition, as occurs from a lack of dopamine, the stimulating chemicals like acetylcholine will have a greater activating presence. Muscles will contract more erratically and firmly leading to the symptoms of the disease.
11. Since the new tissue increases the dopamine levels in the brain restoring the natural inhibition of nerve impulses, patients can show remarkable improvements in muscle control.
12. GABA is also an inhibitor like dopamine. You read about it on page 375 of your text. Therefore, its activity would mimic that of dopamine. Low levels of GABA could not prevent unusually high stimulation to muscles and symptoms such as tremors would be the natural result.

Section 2: Follow-up Activities

Extra Help

1. Each of the descriptions is found in order on pages 366 to 371 in your text.

- a involuntary nerves designed to maintain homeostasis
- l involuntary motor nerves that prepare the body to respond to stress
- g protective membranes that surround the brain and spinal cord
- c outer, grey-matter lining of the cerebral hemispheres
- e lobe of the cerebrum associated with intellectual activity and personality
- j lobe of the cerebrum associated with memory and interpretation of sensations
- n lobe of the cerebrum associated with touch, temperature, and speech
- h lobe of the cerebrum associated with vision
- b region of the brain that coordinates muscle movement
- f region of the brain that joins the spinal cord with the cerebellum

2.
- | Label | Structure Name | Function |
|-------|-------------------|--|
| a. | synaptic vesicles | store and release chemical transmitters |
| b. | axon | transmit the nerve impulse |
| c. | synapse | separate the presynaptic and postsynaptic neurons |
| d. | neurotransmitters | diffuse across the synapse and alter the activity of the postsynaptic neuron |
| e. | receptor sites | receive the transmitter and change the polarity of the postsynaptic neuron |
3.
- Chemical transmitters that inhibit will prevent a nerve from transmitting an impulse. They may do this by increasing the amount of potassium ions (K^+) outside the membrane. This increases the negative charge inside of the postsynaptic neuron and makes the neuron less responsive. Transmitters that stimulate transmission increase the number of sodium ions (Na^+) that move across and depolarize the postsynaptic membrane. They open the membrane to sodium ions. This initiates the transmission of nerve impulses.
4.
- Because there are fewer transmitters released by the presynaptic neuron on the right, Neuron X must have reduced the number of nerve impulses being transmitted.

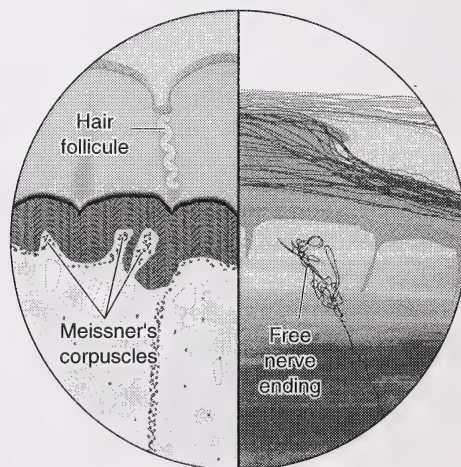
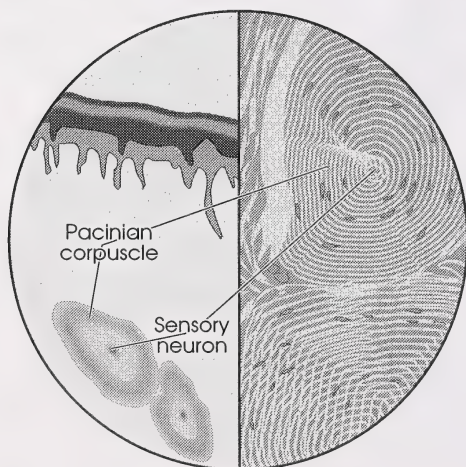
Enrichment

- **Textbook question 1:** Many opinions can be explored. You should listen to other viewpoints. Most importantly, you should recognize that the answer to the question is found not within the discipline of science, but of ethics. The question illustrates the limits of using a scientific method for problem solving. It is important for you to recognize that the tissues are not taken from living fetuses. Have you considered that organs for transplants have been taken from other life forms? In Chapter 18 you may have read about the transplant of liver cells from a mother to her child. A variety of religious concerns may also be expressed. Although not all individuals may agree with your beliefs, it is important that you respect and acknowledge others.
- **Textbook question 2:** Western science is based on determining cause-and-effect relationships. Each step is broken down to causal relationships in an attempt to find an answer. Eastern science, by contrast, traditionally has looked at questions more holistically. Not all of the answers for acupuncture are known. Therefore, western scientists approach it cautiously. Acupressure is another branch of this discipline. Interestingly, an acupressure device called sea-band has been developed to alleviate nausea from motion sickness. Sea-bands are available at some pharmacies.
- **Textbook question 3:** A variety of opinions can be explored. Advertisers will indicate that their intention is to provide the public with needed information. Responsible advertising must be informative, but it must also be entertaining enough to capture the attention of the viewing audience. You might also explore the implications of not taking pain-killing drugs. Do individuals build up a tolerance against the painkillers? Do these drugs cause side effects? What are the implications of not reducing pain levels for individuals who are suffering? Expect your solutions to differ widely.
- **Textbook question 4:** This question helps you engage in a conversation that provides a better understanding of the nature of scientific research. Determining whether or not a drug should be taken requires careful examination of risks and benefits. It is important to note, however, that genetic diversity within a population makes analysis of risks very difficult to determine. A drug that might produce no measurable side effect in one person may cause considerable harm for another. You may advocate testing of the drug on many individuals within a population, if they are willing to accept human testing. Random samples are most often suggested. You may suggest using double-blind studies in which one group is unknowingly given a placebo. You may reject human testing altogether.

- **Textbook question 5:** Clearly this question extends beyond the boundaries of science, but requires an understanding of science and technology to frame the question and seek solutions. By approaching this question, you will gain an appreciation of how science and technology are changing the way in which we define life and death. Your answers are rooted in personal, moral, and religious beliefs – and that is as it should be.
- **Textbook question 6:** Completely unfair advantages may be given to males on the basis of skull size in such areas as education or jobs. Females with small skull sizes could unfairly be restricted or denied opportunities. Skull size generally correlates with body size for all individuals.

Section 3: Activity 1

1. • **Review question 1:** Sensory receptors for chemical energy include receptors for taste and smell in the obvious places and also receptors for chemicals such as oxygen in the carotid artery and carbon dioxide in the medulla. You can read more about these on page 301 and 302 in your text. Sensory receptors for mechanical energy include pressure receptors in the skin, proprioceptors in the joints, and balance organs in the inner ear. Receptors for heat energy are found in the skin. Light energy receptors are only found in the eye and receptors for sound are only found in the ear. Shining a flashlight in your ear should not cause a sensation.
 - **Review question 2:** The sensory receptors in humans do not identify all environmental stimuli. For example, humans cannot detect radio waves, nor indeed most of the electromagnetic spectrum apart from visible light.
 - **Review question 3:** Sensory adaptation occurs when sensory receptors become accustomed to an environmental stimulus and fail to respond to it. For example, you quickly become accustomed to the smell of the ocean or to the ticking of a clock in your bedroom.
2. Your diagrams should be similar to the ones shown here.



3. The secondary receptor cells encapsulate the sensory neuron. The free nerve ending was simply the bare dendrites of a sensory neuron.

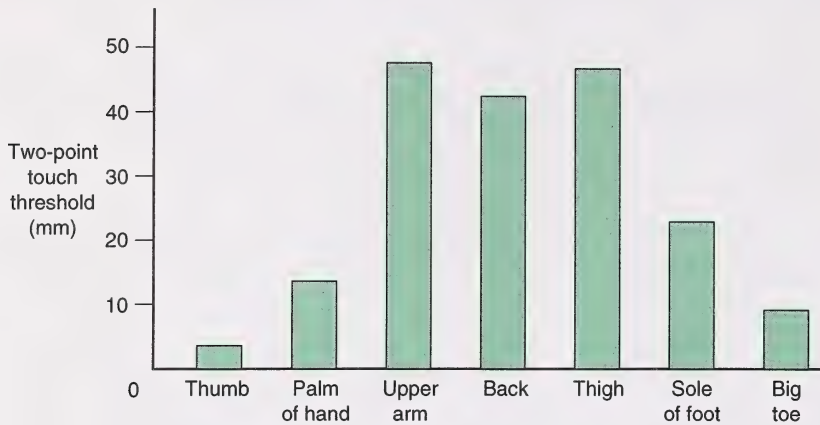
4. The Meissner's corpuscles are found nearer the surface of the skin, so it follows that they would respond to light pressure or touching of the skin. The Pacinian corpuscles are found deeper in the skin and detect heavier pressure. The free nerve endings are distributed near the surface and deeper in the skin. Therefore, they will respond to both stimuli. Damage or overstimulation will produce the sensation of pain.
5. The manipulated variable is the region of the skin to be tested. Each region will have a different density and receptive field area for the touch receptors. The responding variable will be the measured distance for the two-point touch threshold (the diameter of the receptive field).
6. What effect will the region of the body have on the receptive field diameter for the receptors?
7. Many hypotheses are possible. An example is given. The fingertips will have a small receptive field area because they are very sensitive. The two-point touch threshold will be small compared to the big toe or the back. This is only a sample.
8. The materials needed include the following:
 - caliper or geometry compass
 - ruler (mm)
 - subject to test (exposed skin)

The procedure you use should be similar to the one given.

- Set the calipers at 50 mm apart.
 - Touch the selected area of skin.
 - Record whether two points or one point is felt.
 - Reduce the caliper distance by 5 mm and repeat touch test until only one point is felt.
 - Record the two-point touch threshold obtained.
 - Repeat procedure for each of the other areas of skin to be tested.
9. Sample results are provided for you. You may not have sampled all these areas.

Body Region	Two-Point Touch Threshold (mm)
Big toe	10
Sole of foot	22
Calf	48
Thigh	46
Back	42
Abdomen	36
Upper arm	47
Forehead	18
Palm of hand	13
Thumb	3
First finger	2

10. Your bar graph may look like this one. Of course the specific results will vary. Not all of the body regions are shown here and the order differs from the sample chart. You can easily see the difference in sensitivity.



11. If you hypothesized correctly, you would have stated that the larger the two-point touch threshold, the lower the density of receptors and the sensitivity. You may infer that different areas of the body have different densities of touch receptors.
12. One possible answer is that because there are fewer neurons on the back in comparison to the fingertips, the brain cannot discriminate between two points that are close together. This makes the back less sensitive.

Section 3: Activity 2

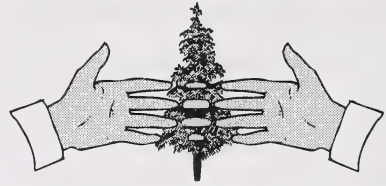
1. • **Review question 6:** The three layers of the eye are the sclera, the choroid layer, and the retina. The sclera is a protective layer, the choroid layer focuses light on the retina, which captures the light and signals the brain.
- **Review question 7:** The eye contains these parts: the vitreous humor, which fills the large chamber behind the lens and maintains the shape of the eye; the aqueous humor, a transparent fluid behind the cornea which supplies the cornea with nutrients and refracts light; the cornea, which is a clear covering over the eye; the pupil, a hole in the iris through which light passes; rods, which respond to low-intensity light; cones, which respond to high-intensity coloured light; the fovea centralis, a very sensitive part of the retina which contains only cones; and the blind spot, the area of the retina where the optic nerve is attached, and which does not contain any rods or cones.

Camera Part	Function in Camera	Part of the Eye
body/case	to support and protect the film	sclera
lens	focuses the image on the film	lens
diaphragm	regulates the amount of light entering	iris
aperture	functions as the hole to allow light in	pupil
film	contains photosensitive chemicals	retina

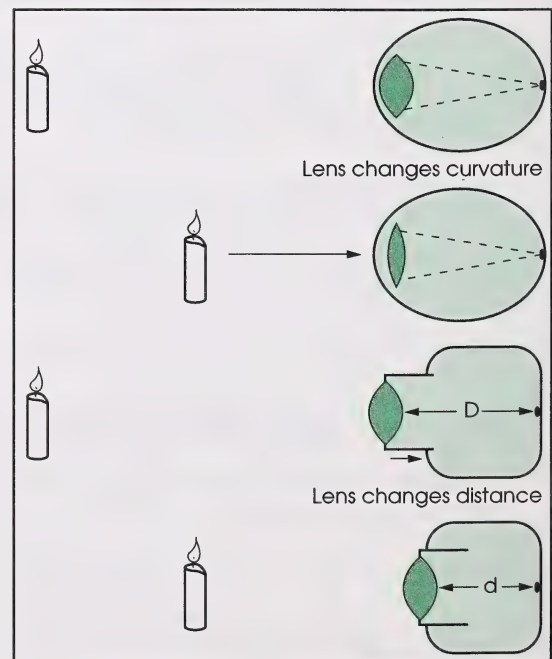
3. This iridescent layer causes the eyes of the animal to reflect light at night and enhances night vision by reflecting some light back into the retina. These nocturnal animals can see better to hunt their prey at night.
4. Incoming light is detected by the rods and cones. These photoreceptors synapse with bipolar cells and generate nerve impulses. The impulses are transmitted to ganglion cells that collectively form the optic nerve. This nerve contains only sensory neurons. Nerve impulse transmission continues toward the brain arriving at the thalamus first. Relay to the primary visual cortex in the occipital lobe is followed by the impulses arriving at the visual association cortex in the parietal lobe. Your brain “sees” light.
5.
 - **Textbook question 8:** Positive afterimages are images that can still be seen after you close your eyes. In the 1880s, Wilhelm Kuhne demonstrated that the retina acts like a photographic film, storing images for a short period of time. Thus, strong images like bright lights will remain on the retina after your eyes are shut.
 - **Textbook question 9:** Accommodation reflexes are adjustments made by the lens and pupil to focus images of objects close to and far away from the eye.
 - **Textbook question 10:** When photons of light strike molecules of rhodopsin, the rhodopsin divides into two components, retinene and opsin. This division produces an action potential, releasing transmitter substances from the end plates of the rods.
 - **Textbook question 11:** Vitamin A is essential for proper vision because it is an essential part of the rhodopsin molecule. Without vitamin A, the molecule cannot form into its light-sensitive structure.
 - **Textbook question 12:** The rods are very sensitive, and in bright light they break down faster than they can reform. Thus, they are most useful in situations where the supply of light is limited.
 - **Textbook question 13:** The cones provide you with colour vision. In the cones, opsin combines with one of three colour-sensitive pigments, either red, blue, or green.
 - **Textbook question 14:** There are several common visual defects. These include glaucoma, which is caused by a buildup of pressure in the aqueous humor; cataract, which is a clouding of the lens or capsule; astigmatism, a condition where the lens or cornea is irregularly shaped; nearsightedness or myopia, where the eyeball is too long; and farsightedness or hyperopia, where the eyeball is too short.
6.
 - **Procedure question a:** If you have normal 20/20 vision you will be able to correctly read the third line from the bottom. Whichever line is clearest indicates the visual acuity for that eye.
 - **Procedure question b:** Generally, both eyes will have the same acuity. It is not unusual, however, for them to be different.
 - **Procedure question c:** Distance may vary from person to person, but most measurements will be between 10 cm and 20 cm.
 - **Procedure question d:** The distance will generally be the same as for the left eye.
 - **Procedure question e:** With both eyes open you probably will see two pencils. When you close one eye you will only see one pencil.
 - **Procedure question f:** Once again, only one pencil will be seen but it may have shifted to the left.
 - **Procedure question g:** You only have two choices. It will move less in either your right eye view or the left. This difference may be difficult to perceive.

- **Procedure question h:** Generally the dominant eye matches the dominant hand but exceptions are common.

- **Procedure question i:** If you are concentrating on a distant object, a totally new set of fingertips will be seen between your hands. It may not be necessary to move your hands towards your face to see this phenomenon.



- **Procedure question j:** You can try this procedure alone by attempting to drop a coin into a cup held at arms' length while holding one eye closed. Using only one eye eliminates your stereoscopic vision and greatly impairs your judgement of distance. Improvement occurs with practice.
 - **Procedure question k:** This may be more of an exercise in coordination than a demonstration of stereoscopic vision. You probably improved your accuracy with each trial.
7. • **Application question 2:** Each eye views the image from a different angle. Depth perception is provided because the brain is able to superimpose one image over another. Stereoscopic lenses work in much the same way.
- **Application question 3:** This increases their field of view. It is more difficult for predators to sneak up on horses and cows. This condition is similar in most ungulates (moose, deer, sheep).
 - **Application question 4:** Animals that live in trees need good depth perception. Estimating the distance of a branch is crucial for an animal living in a tree. Squirrels must also have a wide field of view to detect predators so their eyes are large and partially on the side of the head also.
 - **Application question 5:** No, the two hemispheres do not work independently. One eye always wins out, most often the dominant eye.
8. In order for the camera lens to focus on objects at varying distances, it must move position because its curvature is fixed. The lens of an eye is flexible and changes shape in order to focus. The distance between the lens and the retina is fixed.



Section 3: Activity 3

1. The terms that best fit the descriptions are:

- | | | |
|--------------------------------|---------------------|------------------------|
| a. pinna | e. stapes (stirrup) | i. semicircular canals |
| b. auditory canal | f. oval window | j. cochlea |
| c. tympanic membrane (eardrum) | g. Eustachian tube | |
| d. malleus (hammer) | h. vestibule | |

2. Obviously, anything blocking the auditory canal will be an initial source of interference. Damage to the tympanic membrane or ossicles will be a second source of interference. A third obstacle to the transmission of sound waves is inflammation which produces excess fluid within the middle ear. The accumulation of this fluid may also damage the eardrum. All of these can produce conduction deafness.

3. • **Review question 15:** The external ear collects sound and carries it to the eardrum via the auditory canal. The middle ear starts at the eardrum and extends to the oval and round windows. Sound vibrations that strike the eardrum are amplified and concentrated as they are transferred to the oval window. The inner ear identifies sound waves and converts them into nerve impulses.
- **Review question 16:** The tympanic membrane, or eardrum, concentrates sounds to the ossicles. The ossicles then transfer the sound vibrations to the oval window. The oval window has a much smaller surface area than the tympanic membrane; thus, the sound is greatly amplified.
- **Review question 18:** Boyle was not able to hear the alarm in the bell jar because sound requires a medium, usually air or water, in order to propagate or transmit. The inside of the bell jar was a vacuum; thus, no sound was heard.
- **Review question 19:** As a safety mechanism, these small structures in the middle ear partially immobilize the malleus and move the stapes away from the oval window, thus, reducing the intensity of sounds.

4. Pinna → Auditory canal → Tympanum → Malleus



Incus



Organ of Corti ← Fluid ← Oval Window ← Stapes



Hair cells



Auditory nerve → Thalamus → Primary auditory cortex in temporal lobes



Auditory association cortex in parietal lobes

This completed pathway shows you how the brain integrates the impulses from the auditory nerves so that the brain hears sounds.

5. The round window vibrates in response to perilymph vibrations and dissipates the sound into the air of the middle ear. Louder sounds dissipating can cause the ossicles to vibrate again and stimulate the oval window to vibrate. This is a “ringing” or reverberation in your ears. A jarring of the head could cause a similar response.
6. High frequencies or high pitches are discriminated by the short fibres near the base of the cochlea. Low frequencies or low pitches are discriminated by the long fibres near the apex of the cochlear duct.
7.
 - a. This vibration will be of a medium amplitude sound like the gentle hum of a motor.
 - b. The amplitude of this sound is less, so it will not produce as loud a noise. Its frequency is greater, so it will be a higher pitch or note.
 - c. This vibration will produce the highest pitch sound, but the amplitude is lower yet.
8.
 - **Review question 17:** The inner ear has two functions: it is associated with both balance and hearing. The cochlea, organ of Corti, oval window, and round window are associated with hearing. The saccule, ampulla, and semicircular canals are associated with balance.
 - **Review question 21:** The saccule and utricle are two fluid-filled sacs. The jelly-like fluid contains calcium carbonate particles known as otoliths. Cilia in the sacs interpret the movement of the otoliths, providing information about the head position.
 - **Review question 22:** Three fluid-filled semicircular canals provide information about body movement. Movement of the head causes the fluid in the canals to move, which bends the cilia. The bent cilia initiate nerve impulses, which are carried to the brain and interpreted as body movements.
9. If no nerve impulses are able to arrive in the cerebellum from the vestibular nerves, you will not be able to discriminate equilibrium. You will not be aware of body movement or the position of your body. Only your eyes will help you with equilibrium.
10.
 - **Procedure question a:** It appears to come from the right ear.
 - **Procedure question b:** The sound intensity seems to increase once the right ear is closed.
 - **Procedure question c:** It appears to come from the left ear.
 - **Procedure question d:** The sound intensity seems to increase.
 - **Procedure question e:** Sound travelling through the meter stick seems more intense.
 - **Procedure question f:** The subject leaned in the opposite direction to the spinning: to the left.
 - **Procedure question g:** The subject leaned to the right.
 - **Procedure question h:** The subject usually feels as if he or she is falling.
11.
 - **Application question 1:** Sound waves are conducted faster through denser media. By closing the ear, vibrations travel through bone, which is denser than air. The sound intensity increases as sound waves move through bone. Much the same phenomenon occurs when sound waves travel through the wooden or plastic meter stick.
 - **Application question 2:** The denser the media are, the greater the sound intensity is. Although liquids are not used, solids have greater density than air.
 - **Application question 3:** The subject who was rotated in the chair continued to experience the rotational stimulus even after it had ended. Students also know that they feel dizzy even after they stop spinning. Once the fluid stops, the dizzy sensation stops.

- **Application question 4:** By placing the head on the shoulder, the fluid in the vertical semicircular canal is set into motion by a horizontal rotational stimulus. Once the head is lifted from the shoulder the inertia of the fluid causes it to continue moving; however, the movement is now vertical. The subject feels as if he or she is falling or dropping.
- **Application question 5:** As you move downward along the roller coaster, the fluid in the vertical semicircular canals moves upward. Actually the canal begins moving prior to the fluid. Once the fluid (endolymph) is set into motion, it continues in motion even after the subject changes direction. Eventually, the downward motion of the subject reverses the movement of fluids in the semicircular canal, causing a downward sensation. For a split second the visual information does not match the sensory information provided by the semicircular canals, causing motion sickness. Once again the subject is pushed upward.

Section 3: Follow-up Activities

Extra Help

1.

Somatic Sense Receptors	Special Sense Receptors
pressure proprioceptors	taste buds smell – olfactory cells
thermoregulators	balance – vestibule ear – organ of Corti eye – rods, cones

2.
- The receptor detects a specific stimulus. It will induce nerve impulses in sensory neurons that relay the detection of the stimulus to the brain. A specialized area of the brain interprets the frequency and source of the impulses and creates a sensation. Stimulating that portion of the brain directly will produce the same sensation.

3.

	^a H	^b A																	
^c C	Y	U					^d F					^e O							
A	P	D			^f A	C	C	O	M	M	O	D	A	T	I	^g O	N		
T	E	I			S		V						O		C				
A	R	T			T		^h T	E	M	ⁱ P	O	R	A	L	C				
^j R	H	O	D	O	P	S	I	N		A	I			I	I				
A	P	R			G	^k C				N			T	P					
C	I	Y			M	O				N			H	I					
T	A				A	C			A				S	T					
^l O					T	H											A		
S				^m C	I	L		ⁿ V		^o C	A	N	A	L					
S			^p R	O	D	S	E	E		E									
I	^q I		N	M	A	S				R									
^r C	O	R	N	E	A			T		E		^s W							
L	I	S			^t E	Q	U	I	L	I	B	R	I	U	^u M				
^v L	E	N	S					B		E	N	Y							
S								U		L	D	O							
								L		L	O	P							
				^w P	R	E	S	S	U	R	E		U	W	I				
												M			A				

Enrichment

1. The information found on page 401 in your text helps you ask the questions that will make your investigation fruitful. Beginning with a high school counsellor or Canada Manpower counsellor, you can obtain numerous sources of information. Then, local colleges or universities can help you determine the appropriate training that is necessary. Finally, visit with someone who is successful in your chosen career to find out how everything works on a day-to-day basis.
2. Reading Braille is possible because of the high tactile acuity of your fingertips. Someone who is experienced can scan words at the same rate as you can read aloud. The CNIB office is a great resource and an excellent place to volunteer some time in helping those who are blind.

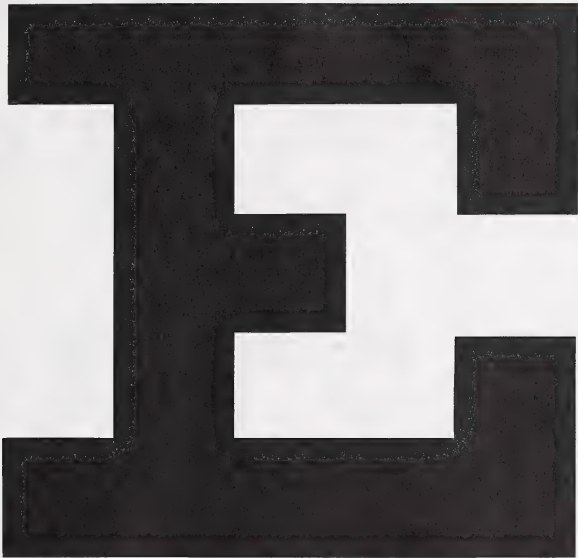
Contact: Canadian National Institute for the Blind
12010 Jasper Avenue
Edmonton, AB
T5K 0P3
Phone: (403) 488-4871

3. Seasonal Affective Disorder (SAD) is a real condition that disrupts the normal activity of humans. Contact your physician for more information about the nature and treatment of this syndrome. If you have access to the eight-part video series, *The Brain* produced by WNET/New York for distribution by PBS, you may enjoy Part 3. It deals with rhythms and drives within the brain which affect sleeping, waking, alertness, competence, and many of your emotions.
4.
 - **Critical-Thinking question 1:** Simple colour discrimination tests might be suggested. It is important to consider the age of the subject, light intensity, and distance from the object. A control should also be introduced. Use the skills you learned in Activity 1 of Section 1.
 - **Critical-Thinking question 2:** Many opinions can be explored. You are encouraged to listen to all other viewpoints. Most importantly, you should recognize that the answer to the question is found not within the discipline of science, but that of ethics. The question illustrates the limits of using a scientific paradigm for problem solving.

Snellen Eye Chart

Tear out these pages and tape them together to form a wall chart.

$\frac{20}{200}$



$\frac{200 \text{ FT.}}{61 \text{ m}}$

$\frac{20}{100}$



$\frac{100 \text{ FT.}}{30.5 \text{ m}}$

$\frac{20}{70}$



$\frac{70 \text{ FT.}}{21.3 \text{ m}}$



$\frac{20}{50}$

L P E D

$\frac{50 \text{ FT.}}{15.2 \text{ m}}$

$\frac{20}{40}$

P E C F D

$\frac{40 \text{ FT.}}{12.2 \text{ m}}$

$\frac{20}{30}$

E D F C Z P

$\frac{30 \text{ FT.}}{9.14 \text{ m}}$

$\frac{20}{25}$

F E L O P Z D

$\frac{25 \text{ FT.}}{7.62 \text{ m}}$

$\frac{20}{20}$

D E F P O T E C

$\frac{20 \text{ FT.}}{6.10 \text{ m}}$

$\frac{20}{15}$

L E F O D P C T

$\frac{15 \text{ FT.}}{4.57 \text{ m}}$

$\frac{20}{13}$

F D P L T C E O

$\frac{13 \text{ FT.}}{3.96 \text{ m}}$

$\frac{20}{10}$

P E Z O L C F T D

$\frac{10 \text{ FT.}}{3.05 \text{ m}}$

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